Report DRD MA-183TF

SHUTTLE S-BAND HIGH GAIN SWITCHED BEAM BREADBOARD ANTENNAS

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19 ABSTRACT (*Continue on reverse if necessary and identify by block number*)

This contractually required Final Report describes final fabrication, assembly and test results of the S-Band Five-Element, Eight-Beam Breadboard Antennas developed for the Space Shuttle Program. Fabrication and assembly section includes information since the last contractual status report (DRD MA-179T).

Test results include those from component and final assembly testing. Data summary sheets from all testing are presented.

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CONTENTS

1. INTRODUCTION AND DESCRIPTION

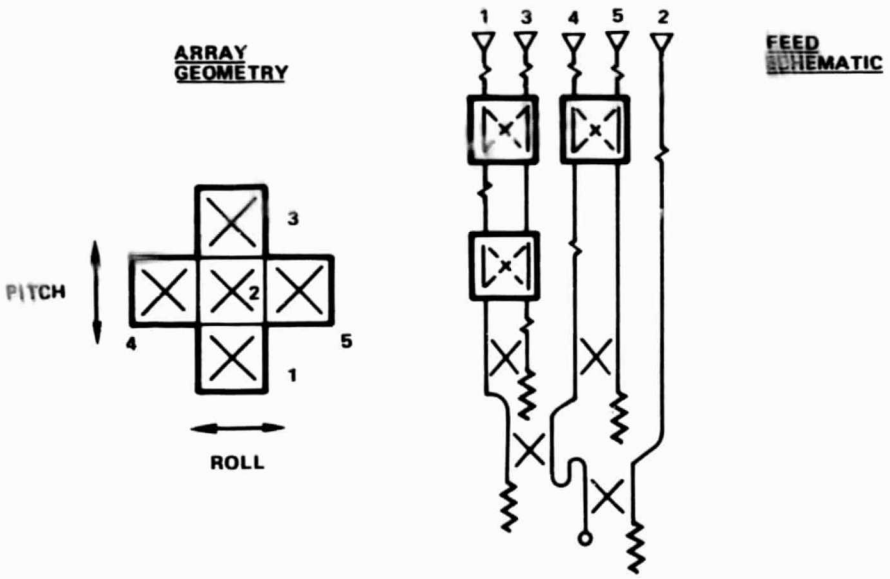
This is the final report for contract NAS9-17006, Shuttle High Gain Breadboard Antennas.

The two Shuttle High Gain Breadboard Antennas will demonstrate the performance of the proposed system, which consists of four of the five-element, eight-beam antennas designed to have improved performance over the existing two-element, two-beam antennas.

Each eight-beam antenna uses five closely spaced radiating elements in a cross formation, which are phase switchable to direct the beam. Power division is accomplished by an integrated stripline coupler assembly and phase tuning is acomplished through the use of precision RF cable lengths. Beam switching is done with three coaxial transfer switches.

The radiating elements are broad-banded crossed dipoles that are fed to provide righthand circular polarization.

The feed network and array geometry used for the eight beam antenna are as shown in the figure below.



2. FINAL FABRICATION AND ASSEMBLY

The upper flange was modified by the placement of additional layers of quartz disks over the radiating elements. This modification was successful in improving the performance.

The RF coaxial switches were originally received from the Novak Corporation in the beginning of August. They were found to have intermittent performance and were returned to the vendor for adjustments. Upon return from the vendor, one of the switches still exhibited intermittency, and the set was determined to be unacceptable for use. Transco Corporation's Engineering Group agreed to supply the program with three switches built from spare parts. These were delivered on October 19, 1984.

RF cable fabrication and phase trimming proved to be very time-consuming due to numerous iterations between proper phase length and mechanical fit

After the final assembly integration, final bench tests were made and pattern testing was begun.

3. TEST RESULTS

3.1 COMPONENT TESTING (REFERENCE ATTACHED DATA SUMMARY SHEETS)

3.1.1 Individual Components

Most of the individual components are common to both the upper and lower antennas. The only exceptions are the five cables which feed the elements and the input cables. The common components are exchanged between the upper and lower flanges and housings.

Two of the three coaxial switches had measured losses within the expected range. However, the third switch measured approximately twice as lossy as normal but was used anyway due to lack of time for the procurement of another switch.

All of the RF cables except for cable "e" (to the center element) measured well below their budgeted loss value. Cable "e" for both the upper and lower antennas measured only slightly more lossy than was predicted.

The stripline power divider network insertion loss measured approximately 0.5 dB better than was predicted through all RF paths. Its input VSWR and returned power to the load ports were low.

3.1.2 Feed Subassembly

The feed subassembly consists of the power divider, the coaxial switches, and the RF cabling. This combination of components measured approximately 0.5 dB more lossy in some cases than was predicted. However, the input VSWR was good. Phase measurements, which were recorded at 2150 MHz only, demonstrated that phasing was held within 7° of design values.

3.1.3 Radiating Subassembly

The radiating subassembly consists of the radiating elements with element couplers, combined with the antenna flange/radome. Input VSWR into both upper and lower units was low. Power at the load ports was reduced by the placement of additional layers of quartz over the apertures. Some values still spiked slightly higher than the target value.

3.2 FINAL ASSEMBLY TESTING

3.2.1 Final Bench Testing

Input VSWR of the complete assembly was generally lower than the budgeted value. Only in beam position 5 on the upper and lower antennas did the VSWR rise higher than the budgeted value. Power at the load ports of the power divider and radiating elements was measured at the complete assembly level. Values for some beam positions exceeded the budgeted values but the general trend was data close to those values.

3.2.2 Radiation Patterns

Proper scan angles for each beam on both the upper and lower antennas were obtained by exciting only one row of elements in the array at a time. Patterns from a given plane were then obtainable with the opposing plane at boresight. The peak gain angles derived in this fashion were then used in testing the full five-element array.

The lower antenna was fully evaluated for gain and axial ratio. Gain measurements for 2041.9 and 2106.4 MHz are slightly less accurate than the other radiation data since the scan angles used at these frequencies were obtained at 2150 MHz. Scan angles typically varied less than 4° from frequency to frequency. However, gain measurements at 2217.5 and 2287.5 MHz, as well as all of the axial ratio measurements were measured using scan angles obtained at the appropriate frequencies.

At 2041.9 MHz, the pitch plane peak gain averaged 6.7 dB; 4.0 dB beamwidth averaged 132.0°; axial ratio at ± 55° averaged 4.8 dB. Roll plane peak gain averaged 6.8 dB; beamwidth averaged 93.5°; axial ratio at ± 50° averaged 5.2 dB.

At 2106.4 MHz, the pitch plane peak gain averaged 6.5 dB; beamwidth averaged 141.5°; axial ratio at ± 55° averaged 5.0 dB. Roll plane peak gain averaged 7.5 dB; beamwidth averaged 119.2°; axial ratio at ± 50° averaged 5.7 dB.

At 2217.5 MHz, the pitch plane peak gain averaged 7.4 dB; beamwidth averaged 123.5°; axial ratio at ± 55° averaged 6.2 dB. Roll plane peak gain averaged 7.2 dB; beamwidth averaged 95.8°; axial ratio at ± 50° averaged 5.2 dB.

At 2287.5 MHz, the pitch plane peak gain averaged 7.4 dB; beamwidth averaged 125.0°; axial ratio at ± 55° averaged 5.7 dB. Roll plane peak gain averaged 7.3 dB; beamwidth averaged 94°; axial ratio at ± 50° averaged 3.7 dB.

4. COMPONENT TEST DATA SUMMARY SHEETS

SPACE SHUTTLE S-BAND HIGH GAIN BREADBOARD ANTENNAS

UPPER _____ LOWER ___√___.

DATA SHEET 1

COMPONENT (REF. SCHEMATIC)	TEST*	ACCEPTANCE CRITERIA		2041.9 MHz				2106.4 MHz				2117.5 MHz				2287.5 MHz			
				POS. 1		POS. 2		POS. 1		POS. 2		POS. 1		POS. 2		POS. 1		POS. 2	
RF SWITCH				J1-J3	J4-J5	J1-J5	J4-J3	J1-J3	J4-J5	J1-J5	J4-J3	J1-J3	J4-J5	J1-J5	J4-J3	J1-J3	J4-J5	J1-J5	J4-J3
NO. 1	F.T.	≥ -.15 dB		-.12	-.12	-.11	-.10	-.15	-.12	-.13	-.10	-.16	-.13	-.14	-.13	-.15	-.13	-.14	-.14
NO. 2				-.11	-.10	-.11	-.12	-.13	-.12	-.13	-.13	-.15	-.14	-.14	-.15	-.15	-.13	-.14	-.14
NO. 3				-.17	-.29	-.20	-.19	-.17	-.29	-.19	-.19	-.19	-.32	-.20	-.20	-.19	-.32	-.21	-.21
INPUT CABLE	F.T.	≥ -15 dB		-.11				-.11				-.14				-.14			
INTERCONNECT		UP.	LOW.																
CABLE a.	F.T.	≥ -.21	≥ -.21	-.09				-.08				-.10				-.10			
b.		.21	.21	-.06				-.06				-.09				-.09			
c.		.20	.20	-.08				08				-.08				-.09			
d.		.21	.21	-.11				-.12				-.12				-.13			
e.		.46	.46	-.37				-.43				-.51				-.47			
f.		.34	.35	-.28				-.29				-.30				-.30			
g.		.34	.34	-.24				-.23				-.29				-.27			
h.		.21	.21	-.11				-.10				-.06				-.08			
i.		.19	.19	-.03				-.04				-.01				-.03			
j.		.27	.27	-.18				-.17				-.17				-.19			
k.		.27	.27	-.12				-.11				-.12				-.15			
PWR. DIVIDER NETWORK																			
PORT A	F.T.	≥ -9.0 dB		- 8.4				- 8.4				- 8.6				- 8.6			
B		≥ -9.0		- 8.4				- 8.3				- 8.4				- 8.4			
C		≥ -9.0		- 8.5				- 8.4				- 8.4				- 8.5			
D		≥ -9.0		- 8.7				- 8.8				- 8.8				- 8.8			
E		≥ -4.0		- 3.8				- 3.7				- 3.6				- 3.6			
INPUT	R.L.	≥ 14.0 dB		23.5				24.0				20.1				17.7			
COUPLER NO. 1	P/L	≤ -14.0 dB		-26.8				-30.0				-42.5				-34.0			
NO. 2		≤ -16.4		-27.8				-26.6				-23.8				-21.8			
NO. 3		≤ -19.5		-22.1				-22.3				-22.8				-22.9			
NO. 4		≤ -19.5		-27.9				-28.3				-29.3				-29.2			

*TEST CODES

F. T. = FORWARD TRANSMISSION, INCLUDING LOSSES

R. L. = RETURN LOSS

P/L = POWER AT LOAD PORTS (ISOLATION)

ALL MEAS. ARE RELATIVE TO INPUT

LOWER ANTENNA
CABLE PHASE MEASUREMENTS
DATA SHEET 2

NOTE: All cable phase measurements relative to cable J (element C). @ 2150 MHz.

CABLE F (ELEMENT A)			
BEAM	**EXPERIMENTAL**	**DESIGN**	**ERROR**
1	lag 142.8	lag 140.0	F long by 2.8
2	lag 52.1	lag 50.0	F long by 2.1
3	lead 34.3	lead 40.0	F long by 5.7
4	lead 124.5	lead 130.0	F long by 5.5
5	lag 7.1	lag 8.0	F short by 0.9
6	lead 83.6	lead 82.0	F short by 1.6
7	lead 170.0	lead 172.0	F long by 2.0
8	lead 260.2	lead 262.0	F long by 1.8
CABLE G (ELEMENT B)			
BEAM	**EXPERIMENTAL**	**DESIGN**	**ERROR**
1	lead 48.2	lead 50.0	G long by 1.8
2	lead 135.4	lead 140.0	G long by 4.6
3	lead 224.5	lead 230.0	G long by 5.5
4	lead 313.0	lead 320.0	G long by 7.0
5	lag 83.3	lag 82.0	G long by 1.3
6	lead 3.7	lead 8.0	G long by 4.3
7	lead 92.6	lead 98.0	G long by 5.4
8	lead 181.4	lead 188.0	G long by 6.6
CABLE K (ELEMENT D)			
BEAM	**EXPERIMENTAL**	**DESIGN**	**ERROR**
1	lag 274.6	lag 270.0	K long by 4.6
2	lag 89.8	lag 90.0	K short by 0.2
3	lead 88.9	lead 90.0	K long by 1.1
4	lead 270.0	lead 270.0	–
5	lag 273.9	lag 270.0	K long by 3.9
6	lag 92.8	lag 90.0	K long by 2.8
7	lead 88.2	lead 90.0	K long by 1.8
8	lead 269.3	lead 270.0	K long by 1.7

SPACE SHUTTLE S-BAND HIGH GAIN BREADBOARD ANTENNAS
UPPER_____ LOWER_✓_____

DATA SHEET 3

FEED SUBASSEMBLY (REF. SCHEMATIC)	TEST*	ACCEPTANCE CRITERIA	2041.9 MHz POS. 1	2	3	4	5	6	7	8	2106.4 MHz POS. 1	2	3	4	5	6	7	8	2217.5 MHz POS. 1	2	3	4	5	6	7	8	2287.5 MHz POS. 1	2	3	4	5	6	7	8
PORT NO 1	F T	-9 7 dB	9 3	9 3	9 3	9 3	9 3	9 2	9 2	9 3	9 3	9 3	9 3	9 3	9 2	9 2	9 2	9 2	9 4	9 4	9 4	9 4	9 3	9 3	9 3	9 3	9 5	9 5	9 5	9 5	9 4	9 4	9 4	9 4
NO 2		-9 7	9 2	9 1	9 1	9 1	9 2	9 2	9 2	9 2	9 1	9 1	9 1	9 1	9 2	9 2	9 2	9 2	9 4	9 3	9 3	9 3	9 4	9 4	9 4	9 4	9 7	9 5	9 5	9 5	9 6	9 6	9 6	9 6
NO 3		-10 0	11 1	9 5	10 5	9 9	11 1	9 5	10 5	9 9	10 3	9 2	10 3	9 7	10 3	9 3	10 4	9 7	10 2	9 7	11 4	9 9	10 2	9 7	11 4	9 8	10 5	9 8	11 3	10 0	10 5	9 8	11 3	9 9
NO 4		-10 0	9 9	10 5	9 5	11 0	9 9	10 4	9 5	11 0	9 6	10 3	9 3	10 0	9 6	10 3	9 3	10 1	10 1	11 0	9 7	9 9	10 1	10 9	9 7	10 0	10 0	11 0	9 9	10 2	10 0	11 0	10 0	10 4
NO 5		-4 5	4 4	4 4	4 4	4 4	4 4	4 3	4 3	4 4	4 3	4 3	4 3	4 3	4 3	4 3	4 3	4 3	4 3	4 4	4 3	4 3	4 3	4 4	4 3	4 3	4 4	4 4	4 4	4 4	4 4	4 3	4 4	4 4
INPUT	R L	-12 0 dB	16 4	16 8	16 7	16 3	16 9	17 3	17 3	16 7	20 7	21 6	20 6	21 4	21 0	22 3	21 2	22 0	16 6	16 2	16 3	16 5	16 5	16 7	16 4	16 6	15 4	16 4	15 7	16 1	15 4	16 2	15 6	16 0
RADIATING SUBASSEMBLY																																		
ELEM COUPLER A	R L	-14 0 dB	18 2								15 2								15 3								17 3							
B			20 3								16 9								15 0								17 6							
C			35 1								22 5								15 3								16 0							
D			23 0								18 9								17 4								18 3							
E			23 2								19 2								16 8								16 0							
ELEM COUPLER A	P L	-14 0 dB	-15 5								-20 4								-17 9								-11 9							
B			-11 8								-14 5								-25 2								-16 3							
C			-18 0								-22 1								-19 7								-14 7							
D			-16 8								-18 7								-16 4								-13 5							
E			-16 0								-18 9								-16 3								-13 8							

*TEST CODES

F T - FORWARD TRANSMISSION, INCLUDING LOSSES
R L - RETURN LOSS
P L - POWER AT LOAD PORTS IISOLATION
ALL MEASURES ARE RELATIVE TO INPUT

SPACE SHUTTLE S-BAND HIGH GAIN BREADBOARD ANTENNAS
UPPER_____ LOWER ✓

DATA SHEET 4

FINAL ASSEMBLY (REF. SCHEMATIC)	TEST*	ACCEPTANCE CRITERIA	2041.9 MHz POS. 1	2	3	4	5	6	7	8	2106.4 MHz POS. 1	2	3	4	5	6	7	8	2217.5 MHz POS. 1	2	3	4	5	6	7	8	2287.5 MHz POS. 1	2	3	4	5	6	7	8
INPUT	R.L.	> 9.5 dB	12.8	14.1	22.1	12.6	9.4	17.5	17.2	10.2	16.2	11.0	13.9	26.1	15.6	22.0	16.2	15.7	10.5	13.0	17.1	11.0	9.0	14.2	13.6	9.0	23.5	13.6	14.5	26.2	23.6	19.6	16.3	22.4
PWR DIVIDER NETWORK																																		
COUPLER NO. 1	P/L	< -14.0 dB	26.7	24.6	18.8	21.4	23.3	20.8	25.1	31.2	20.1	23.4	20.6	18.2	16.9	17.9	19.7	18.2	21.3	21.2	15.7	16.8	18.4	18.3	21.6	25.3	15.2	16.3	20.8	19.4	14.9	17.5	14.9	13.8
NO. 2		< -16.4	13.5	16.9	18.4	21.9	20.8	18.1	18.7	14.4	14.9	18.8	12.6	11.8	12.0	12.8	16.0	14.5	18.4	13.5	17.1	22.1	25.0	16.0	14.5	18.9	21.2	21.6	15.5	18.7	19.5	17.7	19.6	21.6
NO. 3		< -19.0	14.9	15.5	15.6	14.9	18.9	19.8	15.0	14.8	15.2	15.8	16.0	15.7	21.4	23.4	19.2	18.5	16.9	17.0	17.2	17.0	38.5	30.6	25.0	25.1	19.8	19.8	19.6	19.2	27.2	25.2	45.5	33.4
NO. 4		< -19.5	11.8	16.4	16.1	12.1	14.4	19.8	18.7	15.9	21.7	23.7	21.6	20.5	37.6	16.7	18.1	44.9	14.9	29.3	27.3	15.3	15.4	35.0	42.5	16.6	21.1	15.5	14.0	22.7	19.8	14.6	13.3	20.9
ELEM COUPLER A	P/L	< -23.1 dB	22.9	25.4	29.9	23.6	18.5	17.0	17.9	20.4	20.9	23.5	25.4	23.6	18.8	19.6	21.3	20.5	17.2	18.6	20.3	18.0	24.8	31.5	42.6	24.7	15.6	17.4	18.0	16.4	29.6	28.0	26.5	29.8
B		< -23.3	15.4	16.3	14.9	14.1	34.4	20.7	20.6	34.9	16.0	18.3	17.1	15.2	30.6	21.3	20.0	24.7	20.9	26.2	24.0	19.9	22.2	25.2	22.2	21.3	28.5	26.9	25.4	25.7	21.5	28.2	25.9	20.2
C		< -23.6	17.7	18.2	20.7	21.2	22.7	20.8	21.2	32.4	18.0	18.8	20.6	19.7	23.2	22.9	23.4	25.1	19.2	25.3	21.2	18.3	23.9	34.5	28.6	21.3	18.0	35.2	26.9	16.1	19.9	28.9	34.6	18.6
D		< -23.6	23.0	23.0	20.8	19.0	25.4	21.2	19.0	20.0	24.6	24.3	21.4	20.0	24.3	21.0	20.2	21.2	20.8	22.3	24.3	26.2	18.1	20.0	25.9	20.8	18.2	22.9	28.6	23.1	16.2	24.7	44.5	18.9
E		< -19.4	16.2	18.9	18.8	17.0	17.3	14.9	15.0	17.4	20.3	20.7	20.4	20.7	20.1	15.0	14.5	20.7	22.3	19.2	18.8	21.5	25.5	16.3	15.5	25.4	16.4	17.7	16.9	16.9	19.4	16.0	16.1	18.9

*TEST CODES

F.T. - FORWARD TRANSMISSION, INCLUDING LOSSES
R.L. - RETURN LOSS
P/L - POWER AT LOAD PORTS (ISOLATION)
ALL MEASURES ARE RELATIVE TO INPUT

SPACE SHUTTLE S-BAND HIGH GAIN BREADBOARD ANTENNAS

UPPER ✓ LOWER _____

DATA SHEET 1

COMPONENT (REF. SCHEMATIC	TEST*	ACCEPTANCE CRITERIA		2041.9 MHz				2106.4 MHz				2217.5 MHz				2287.5 MHz			
				POS. 1		POS. 2		POS. 1		POS. 2		POS. 1		POS. 2		POS. 1		POS. 2	
RF SWITCH				J1-J3	J4-J5	J1-J5	J4-J3	J1-J3	J4-J5	J1-J5	J4-J3	J1-J3	J4-J5	J1-J5	J4-J3	J1-J3	J4-J5	J1-J5	J4-J3
NO. 1	F.T.	≥ -.15 dB		-.12	-.12	-.11	-.10	-.15	-.12	-.13	-.10	-.16	-.13	-.14	-.13	-.15	-.13	-.14	-.14
NO. 2				-.11	-.10	-.11	-.12	-.13	-.12	-.13	-.13	-.15	-.14	-.14	-.15	-.15	-.13	-.14	-.14
NO. 3				-.17	-.29	-.20	-.19	-.17	-.29	-.19	-.19	-.19	-.32	-.20	-.20	-.19	-.32	-.21	-.21
INPUT CABLE	F.T.	≥ -.15 dB		-.09				-.08				-.08				-.09			
INTERCONNECT CABLE		UP	LOW																
a.	F.T.	≥ -.21	≥ -.21	-.09				-.08				-.10				-.10			
b.		.21	.21	-.06				-.06				-.09				-.09			
c.		.20	.20	-.08				-.08				-.08				-.09			
d.		.21	.21	-.11				-.12				-.12				-.13			
e.		.46	.46	-.40				-.43				-.42				-.47			
f.		.34	.35	-.20				-.19				-.28				-.32			
g.		.34	.34	-.21				-.20				-.23				-.24			
h.		.21	.21	-.11				-.10				-.06				-.08			
i.		.19	.19	-.03				-.04				-.01				-.03			
j.		.27	.27	-.17				-.17				-.19				-.20			
k.		.27	.27	-.13				-.12				-.12				-.11			
PWR. DIVIDER NETWORK																			
PORT A	F.T.	≥ -9.0 dB		-8.4				-8.4				-8.6				-8.6			
B		≥ -9.0		-8.4				-8.3				-8.4				-8.4			
C		≥ -9.0		-8.5				-8.4				-8.4				-8.5			
D		≥ -9.0		-8.7				-8.8				-8.8				-8.8			
E		≥ -4.0		-3.8				-3.7				-3.6				-3.6			
INPUT	R.L.	≥ 14.0 dB		23.5				24.0				20.1				17.7			
COUPLER NO. 1	P/L	≤ -14.0 dB		-26.8				-30.0				-42.5				-34.0			
NO. 2		≤ -16.4		-27.8				-26.6				-23.0				-21.8			
NO. 3		≤ -19.5		-22.1				-22.3				-22.8				-22.9			
NO. 4		≤ -19.5		-27.9				-28.3				-29.3				-29.2			

*TEST CODES

F.T. = FORWARD TRANSMISSION, INCLUDING LOSSES

R.L. = RETURN LOSS

P/L = POWER AT LOAD PORTS (ISOLATION)

ALL MEAS. ARE RELATIVE TO INPUT

UPPER ANTENNA
CABLE PHASE MEASUREMENTS
DATA SHEET 2

NOTE: All cable phase measurements relative to cable J (element C). @ 2150 MHz.

CABLE F (ELEMENT A)			
BEAM	**EXPERIMENTAL**	**DESIGN**	**ERROR**
1	lag 119.0	lag 122.0	F short by 2.8
2	lag 31.6	lag 32.0	F short by 0.4
3	lead 61.7	lead 58.0	F short by 3.7
4	lead 146.1	lead 148.0	F long by 1.9
5	lead 13.7	lead 10.0	F short by 3.7
6	lead 100.8	lead 100.0	F short by 0.8
7	lead 195.3	lead 190.0	F short by 5.3
8	lead 279.9	lead 280.0	F long by 0.1

CABLE G (ELEMENT B)			
BEAM	**EXPERIMENTAL**	**DESIGN**	**ERROR**
1	lead 33.0	lead 32.0	G short by 1.0
2	lead 120.5	lead 122.0	G long by 1.5
3	lead 213.4	lead 212.0	G short by 1.4
4	lead 298.6	lead 302.0	G long by 3.4
5	lag 98.2	lag 100.0	G short by 1.8
6	lag 10.9	lag 10.0	G long by 0.9
7	lead 82.1	lead 80.0	G short by 2.1
8	lead 166.8	lead 170.0	G long by 3.2

CABLE K (ELEMENT D)			
BEAM	**EXPERIMENTAL**	**DESIGN**	**ERROR**
1	lag 266.5	lag 270.0	K short by 3.5
2	lag 93.6	lag 90.0	K long by 3.6
3	lead 92.3	lead 90.0	K short by 2.3
4	lead 265.4	lead 270.0	K long by 4.6
5	lag 266.1	lag 270.0	K short by 3.9
6	lag 93.0	lag 90.0	K long by 3.0
7	lead 92.4	lead 90.0	K short by 2.4
8	lead 264.2	lead 270.0	K long by 5.8

SPACE SHUTTLE S-BAND BREADBOARD ANTENNAS
UPPER ✓ LOWER _____

DATA SHEET 3

FEED SUBASSEMBLY (REF. SCHEMATIC)	TEST*	ACCEPTANCE CRITERIA	2041.9 MHZ								2106.7 MHz								2217.5 MHz								2287.5 MHZ							
			POS.								POS.								POS.								POS.							
			1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
PORT NO 1	F T	≥ -9.7 dB	9.2	9.1	9.1	9.1	9.0	8.9	8.9	8.9	9.3	9.2	9.2	9.2	9.1	9.0	9.1	9.1	9.3	9.3	9.3	9.3	9.1	9.1	9.1	9.1	9.4	9.4	9.4	9.4	9.2	9.2	9.2	9.2
NO 2		≥ -9.7	9.0	9.1	9.0	9.0	9.1	9.1	9.1	9.1	9.0	9.2	9.0	9.0	9.1	9.1	9.1	9.1	9.1	9.3	9.1	9.0	9.2	9.2	9.2	9.2	9.1	9.2	9.1	9.1	9.3	9.2	9.2	9.3
NO 3		≥ -10.0	11.0	9.2	10.4	9.7	11.0	9.2	10.4	9.7	10.4	9.2	10.4	9.6	10.4	9.2	10.4	9.6	10.1	9.4	11.3	9.6	10.1	9.4	11.3	9.6	10.4	9.5	11.2	9.8	10.4	9.5	11.1	9.8
NO 4		≥ -10.0	9.7	10.2	9.4	10.6	9.7	10.2	9.4	10.7	9.6	10.2	9.2	10.1	9.6	10.3	9.2	10.1	9.9	10.7	9.5	9.7	9.9	10.7	9.5	9.7	9.9	10.7	9.8	10.0	9.9	10.8	9.8	10.0
NO 5		≥ -4.5	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
INPUT	R L	≥ 12.0 dB	17.7	21.0	19.4	17.1	17.3	20.0	18.6	17.9	20.8	24.2	21.4	21.4	20.0	23.0	20.6	22.2	18.1	22.2	20.5	20.5	18.4	22.4	20.7	20.4	15.7	16.0	14.9	16.8	16.9	17.1	15.9	18.0
RADIATING SUBASSEMBLY																																		
ELEM. COUPLER A	R L	≥ 14.0 dB	18.3								16.8								15.2								16.7							
B			19.5								16.3								15.4								17.5							
C			25.9								20.5								16.3								18.4							
D			21.8								17.8								16.7								18.0							
E			21.3								19.4								17.5								17.8							
ELEM. COUPLER A	P/L	≤ -14.0 dB	-15.1								-22.3								-16.8								-11.8							
B			-14.4								-19.2								-19.9								-13.5							
C			-16.7								-22.6								-21.3								-15.3							
D			-14.9								-18.9								-23.6								-15.8							
E			-16.1								-21.7								-20.3								-14.3							

*TEST CODES

F.T. = FORWARD TRANSMISSION, INCLUDING LOSSES
R.L. = RETURN LOSS
P/L = POWER AT LOAD PORTS (ISOLATION
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SPACE SHUTTLE S-BAND HIGH GAIN BREADBOARD ANTENNAS
UPPER ✓ LOWER _____

DATA SHEET 4

FINAL ASSEMBLY (REF. SCHEMATIC)	TEST*	ACCEPTANCE CRITERIA	2041.9 MHz POS. 1	2	3	4	5	6	7	8	2106.4 MHz POS. 1	2	3	4	5	6	7	8	2217.5 MHz POS. 1	2	3	4	5	6	7	8	2287.5 MHz POS. 1	2	3	4	5	6	7	8
INPUT	R.L.	≥ 9.5 dB	13.6	17.2	35.0	12.7	10.8	26.8	21.6	12.9	21.2	14.0	18.2	20.8	20.0	21.6	15.9	20.8	10.0	15.7	15.4	10.0	9.4	16.8	14.9	10.3	26.0	16.8	15.7	18.0	16.0	20.0	18.2	22.0
PWR DIVIDER NETWORK																																		
COUPLER NO. 1	P/L	≤ -14.0 dB	-25.7	-28.9	-23.1	-34.6	-27.7	-25.3	-30.3	-24.0	-25.3	-35.3	-23.0	-23.6	-20.1	-21.4	-27.4	-26.1	-25.3	-27.7	-18.2	-20.2	-20.1	-20.2	-25.8	-35.6	-14.5	-15.9	-19.0	-17.6	-16.8	-19.9	-16.2	-14.6
NO. 2		≤ -16.4	-12.5	-20.0	-18.4	-13.5	-13.4	-20.9	-19.2	-15.3	-23.3	-19.6	-17.6	-22.6	-32.4	-18.2	-16.8	-29.9	-16.4	-31.4	-35.9	-18.7	-16.2	-28.2	-36.2	-19.2	-20.6	-15.4	-14.1	-23.5	-19.0	-14.8	-13.6	-22.2
NO. 3		≤ -19.5	-15.3	-14.9	-16.5	-16.2	-16.4	-16.5	-14.3	-14.4	-15.1	-15.8	-16.7	-16.0	-18.9	-20.0	-17.6	-17.1	-22.7	-23.7	-24.8	-24.4	-28.1	-27.6	-28.1	-29.5	-26.2	-23.6	-25.3	-24.8	-23.4	-22.3	-23.9	-24.7
NO. 4		≤ -19.5	-13.3	-17.9	-17.3	-19.5	-21.0	-18.6	-17.1	-12.8	-15.0	-17.2	-11.8	-12.3	-11.8	-11.7	-17.5	-15.8	-18.9	-14.0	-16.9	-22.4	-25.1	-17.3	-13.9	-16.8	-22.4	-23.0	-14.7	-20.2	-18.0	-6.5	-19.9	-22.6
ELEM. COUPLER A	P/L	≤ -23.3 dB	-23.1	-29.8	-32.3	-23.4	-17.7	-17.9	-10.9	-19.2	-20.1	-24.0	-27.3	-22.9	-17.7	-19.3	-20.9	-18.8	-18.4	-20.1	-21.9	-18.5	-25.1	-26.9	-28.5	-27.2	-16.1	-18.0	-19.3	-17.0	-40.4	-23.6	-23.4	-34.3
B		≤ -23.3	-18.7	-18.4	-17.1	-16.8	-28.3	-25.7	-26.2	-28.0	-17.8	-19.3	-18.2	-16.3	-27.4	-25.4	-23.1	-24.3	-27.0	-30.2	-27.4	-21.1	-21.2	-25.4	-22.0	-20.0	-40.9	-24.2	-23.4	-34.6	-18.8	-22.6	-21.6	-18.1
C		≤ -23.6	-16.7	-18.6	-24.0	-19.0	-19.0	-21.3	-25.8	-21.9	-16.5	-19.5	-21.7	-19.2	-19.8	-22.3	-25.7	-23.0	-18.5	-24.0	-24.6	-18.2	-22.0	-31.3	-30.5	-20.9	-17.0	-28.5	-29.1	-16.4	19.2	-27.4	-45.1	-18.6
D		≤ -23.6	-19.4	-27.7	-20.8	-17.2	-19.1	-24.6	-17.5	-16.8	-20.7	-27.7	-21.4	-16.9	-20.1	-22.6	-18.6	-16.6	-20.6	-29.3	-29.1	-20.7	-18.9	-24.3	-23.0	-18.4	-18.4	-30.1	-31.7	-20.1	-17.7	-33.6	-29.5	-17.9
E		≤ -18.4	-15.3	-20.5	-20.2	-15.9	-15.8	-18.1	-18.9	-15.7	-18.1	-22.2	-22.8	-18.1	-18.4	-19.8	-19.9	-19.3	-21.2	-22.9	-23.5	-20.9	-23.5	-22.4	-21.4	-23.2	-17.0	-20.4	-19.4	-17.2	-18.8	-20.3	-20.3	-18.3

*TEST CODES

F.T. = FORWARD TRANSMISSION, INCLUDING LOSSES
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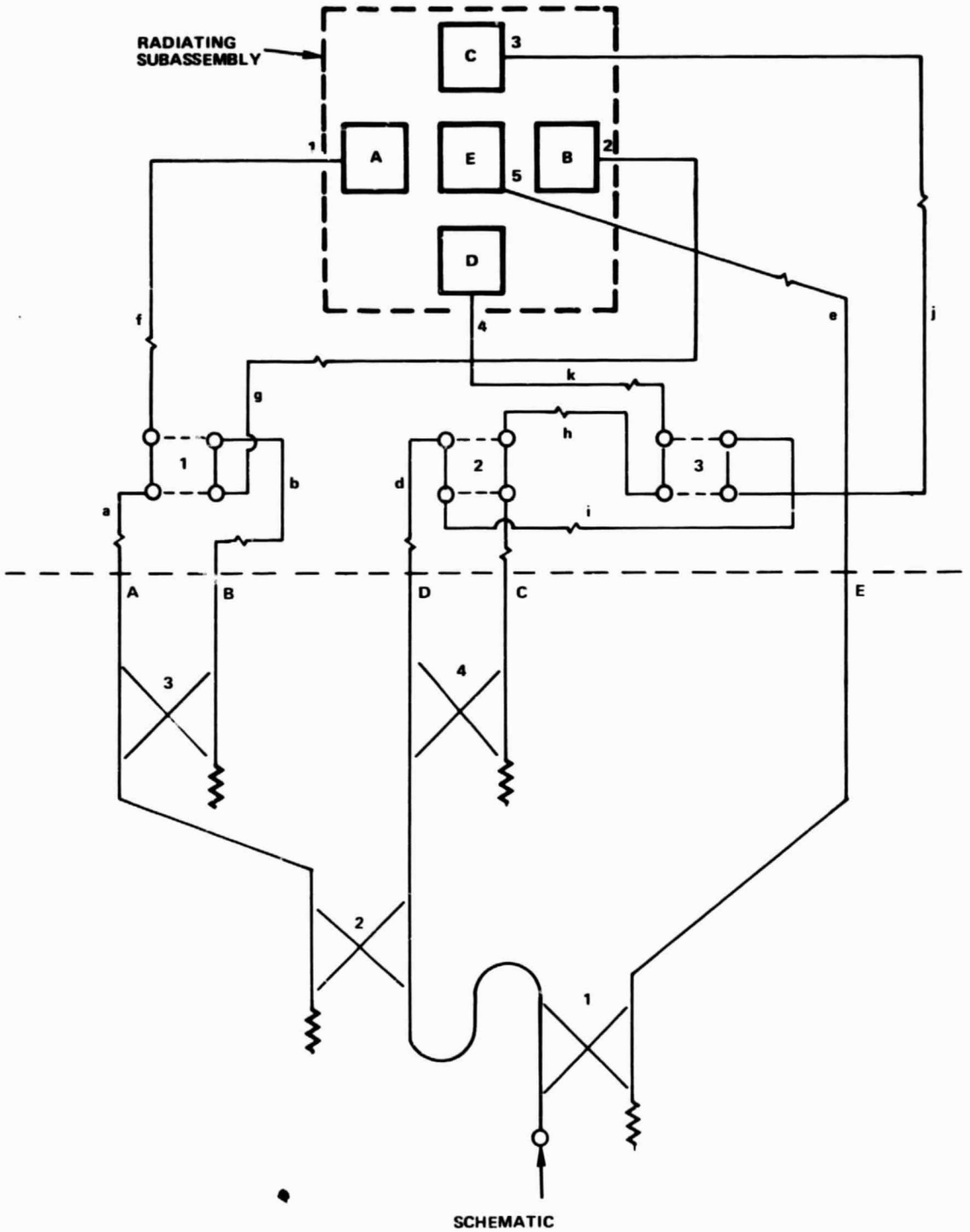
P/L = POWER AT LOAD PORTS (ISOLATION
ALL MEASURES ARE RELATIVE TO INPUT.



SPACE SHUTTLE S-BAND HIGH GAIN ANTENNA

5. RADIATION PATTERN DATA SUMMARY SHEETS

LOWER PITCH PLANE 2041.9 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1	4.0	4.5	138°	142°
2	5.2	7.1		
3	5.4	7.3		
4	6.2	5.4		
5	6.2	6.3	126°	132°
6	4.3	8.2		
7	2.8	8.6		
8	2.9	6.3		

LOWER PITCH PLANE 2106.4 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1	4.6	2.9	142°	148°
2	6.0	6.6		
3	4.5	7.6		
4	6.8	5.6		
5	6.5	5.0	141°	147°
6	4.4*	8.3		
7	3.2	9.3		
8	2.0	6.8		

* At 50°

LOWER ROLL PLANE 2041.9 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1 5	4.7 9.4	5.4 7.6	116°	124°
2 6	3.2 4.4	8.2 8.2	120°	126°
3 7	3.0 2.4	7.9 7.7	112°	117°
4 8	10.4 4.0	4.7 4.4	26°	45°

LOWER ROLL PLANE 2106.4 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1 5	3.0 14.1	6.3 8.2	123°	128°
2 6	2.8 4.4	8.6 8.4	119°	123°
3 7	2.6 3.8	8.2 9.0	119°	123°
4 8	11.4 3.2	5.5 5.9	116°	123°

LOWER PITCH PLANE 2217.5 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1	5.5	4.4	123°	136°
2	6.2	8.1		
3	6.0	8.5		
4	8.7	5.8		
5	8.6	6.6	124°	129°
6	4.1	9.4		
7	2.1	9.6		
8	1.9	6.8		

LOWER PITCH PLANE 2287.5 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1	4.0	4.7	129°	135°
2	4.4	7.6		
3	5.7	6.8		
4	3.2	5.2		
5	8.8	7.6	121°	127°
6	4.2	9.6		
7	2.6	9.5		
8	1.7	7.9		

LOWER ROLL PLANE 2217.5 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1 5	5.9 10.0	3.8 6.1	49°	56°
2 6	3.4 5.9	8.1 9.4	114°	118°
3 7	2.7 3.2	8.4 9.8	113°	118°
4 8	8.2 2.0	6.2 5.6	107°	111°

LOWER ROLL PLANE 2287.5 MHz			BEAMWIDTH	
BEAM	A.R. AT ± 50°	GAIN dBci	4.0 dBci	3.5 dBci
1 5	3.3 8.2	4.7 6.2	56°	62°
2 6	1.7 3.0	8.7 9.8	109°	113°
3 7	1.7 3.0	8.8 9.4	106°	111°
4 8	6.8 2.1	5.3 5.5	105°	112°

6. OFFSITE TEST INSTALLATION REPORT

The upper and lower antennas are mounted into their respective mock-ups in the same fashion as the presently used two beam antennas.

The scan angles determined at Rockwell - Anaheim are listed in the following pages. They can be used to approximately locate beam peaks. Variations from these angles will occur due to mock-up and range differences.

EIGHT BEAM ANTENNA SCAN ANGLES

UPPER ANTENNA

2041.9 MHz

	BEAMS	SCAN ANGLE
ROLL	1 and 5	54.5° down
	2 and 6	19.0° down
	3 and 7	17.0° up
	4 and 8	55.5° up
PITCH	1 thru 4	39.5° down
	5 thru 8	33.5° up

2106.4 MHz

	BEAMS	SCAN ANGLE
ROLL	1 and 5	55.5° down
	2 and 6	18.5° down
	3 and 7	17.0° up
	4 and 8	57.0° up
PITCH	1 thru 4	38.0° down
	5 thru 8	32.0° up

EIGHT BEAM ANTENNA SCAN ANGLES (UPPER ANTENNA) (Continued)

2217.5 MHz

BEAMS	SCAN ANGLE
ROLL 1 and 5	53.5° down
ROLL 2 and 6	14.5° down
ROLL 3 and 7	21.5° up
ROLL 4 and 8	53.5° up
PITCH 1 thru 4	32.5° down
PITCH 5 thru 8	27.0° up

2287.5 MHz

BEAMS	SCAN ANGLE
ROLL 1 and 5	54.0° down
ROLL 2 and 6	15.0° down
ROLL 3 and 7	13.0° up
ROLL 4 and 8	53.5° up
PITCH 1 thru 4	32.5° down
PITCH 5 thru 8	27.5° up

EIGHT BEAM ANTENNA SCAN ANGLES

LOWER ANTENNA

2041.9 MHz

	BEAMS	SCAN ANGLE
ROLL	1 and 5	53.0° down
	2 and 6	21.5° down
	3 and 7	17.5° up
	4 and 8	53.0° up
PITCH	1 thru 4	38.5° down
	5 thru 8	19.5° up

2106.4 MHz

	BEAMS	SCAN ANGLE
ROLL	1 and 5	57.0° down
	2 and 6	19.0° down
	3 and 7	18.0° up
	4 and 8	54.0° up
PITCH	1 thru 4	40.0° down
	5 thru 8	20.5° up

EIGHT BEAM ANTENNA SCAN ANGLES (LOWER ANTENNA) (Continued)

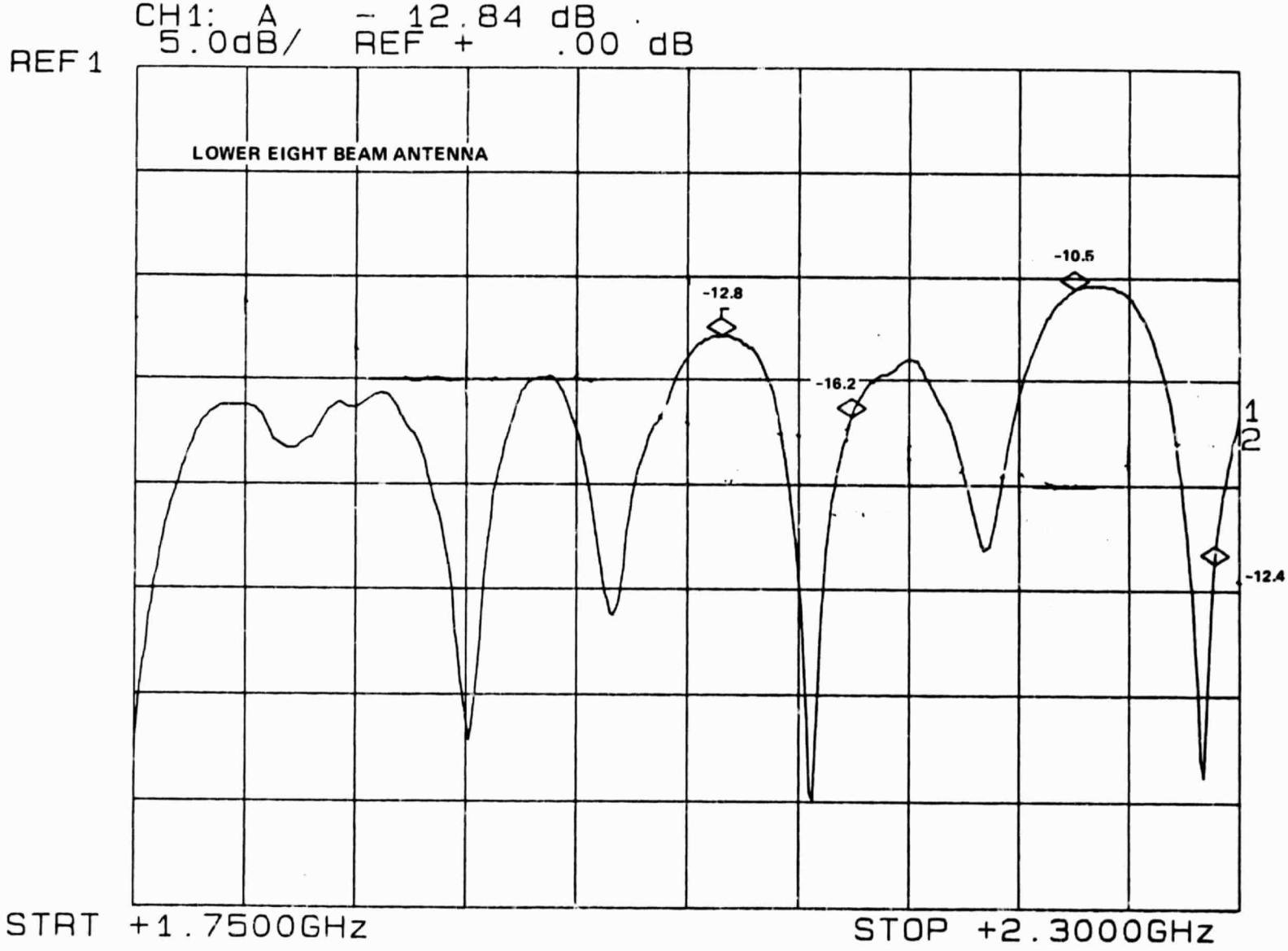
2217.5 MHz

BEAMS	SCAN ANGLE
ROLL 1 and 5	52.5° down
ROLL 2 and 6	17.5° down
ROLL 3 and 7	13.5° up
ROLL 4 and 8	48.5° up
PITCH 1 thru 4	46.0° down
PITCH 5 thru 8	14.5° up

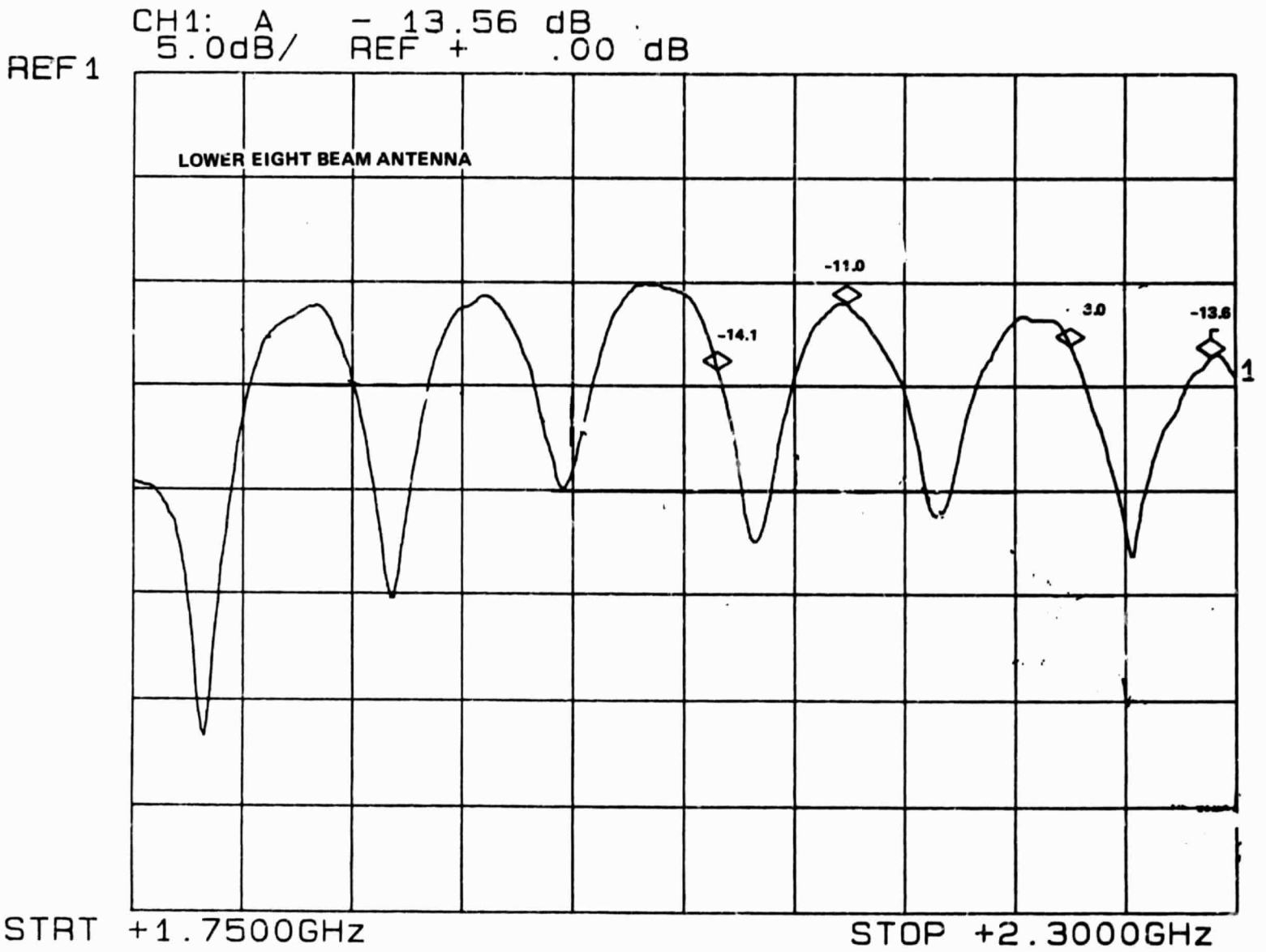
2287.5 MHz

BEAMS	SCAN ANGLE
ROLL 1 and 5	53.5° down
ROLL 2 and 6	11.5° down
ROLL 3 and 7	11.0° up
ROLL 4 and 8	52.5° up
PITCH 1 thru 4	43.0° down
PITCH 5 thru 8	13.0° up

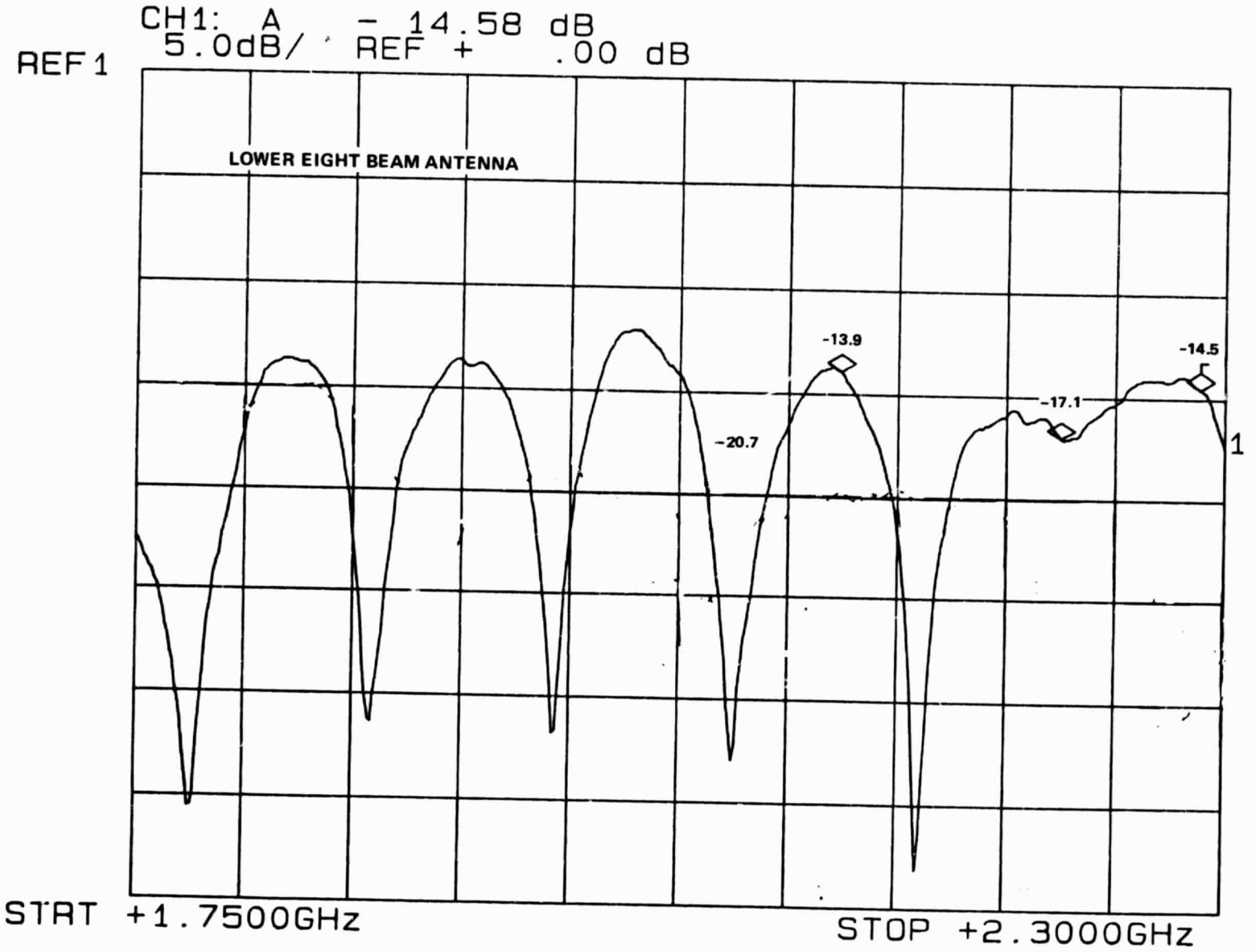
7. RETURN LOSS PLOTS



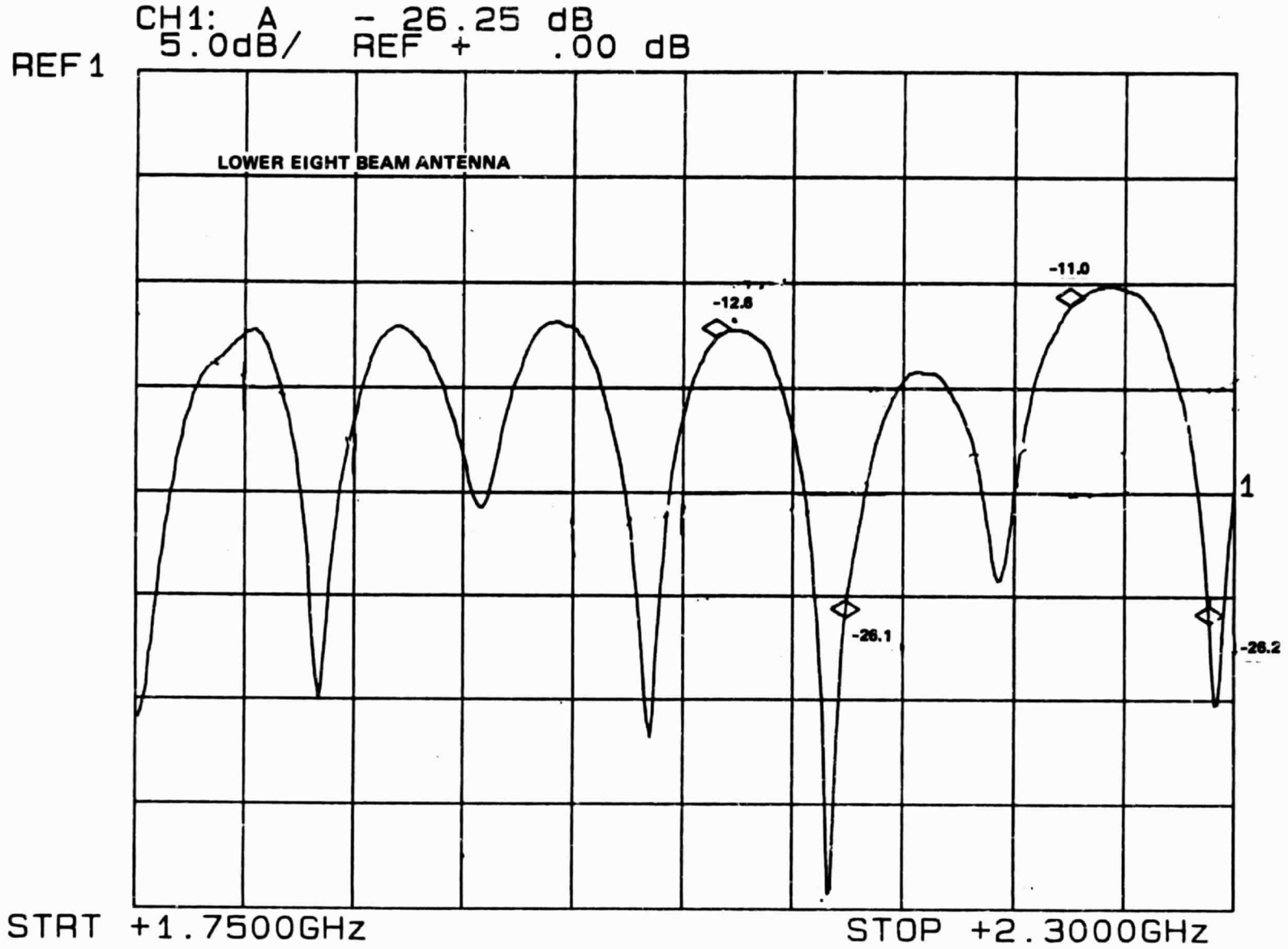
RETURN LOSS – BEAM 1



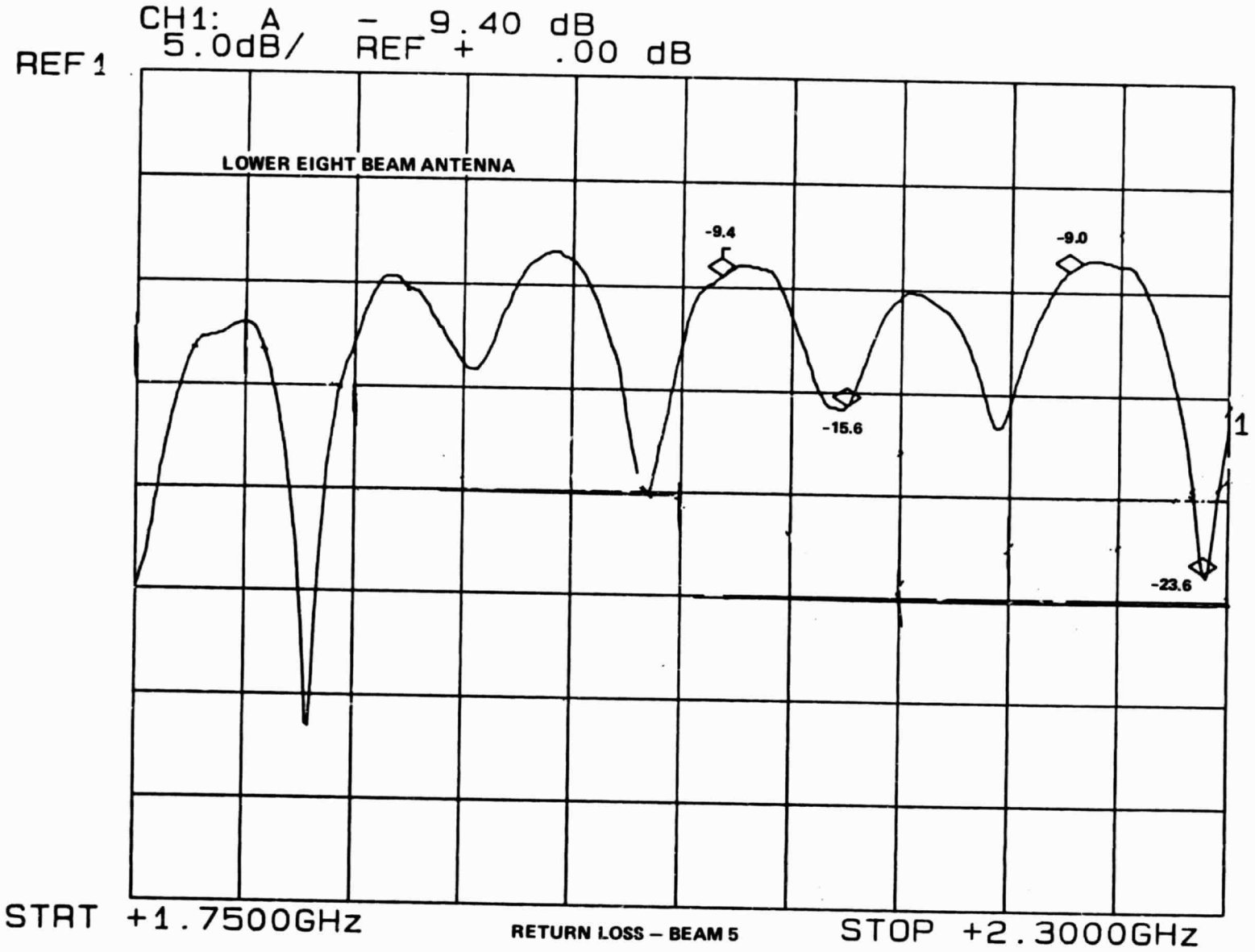
RETURN LOSS – BEAM 2

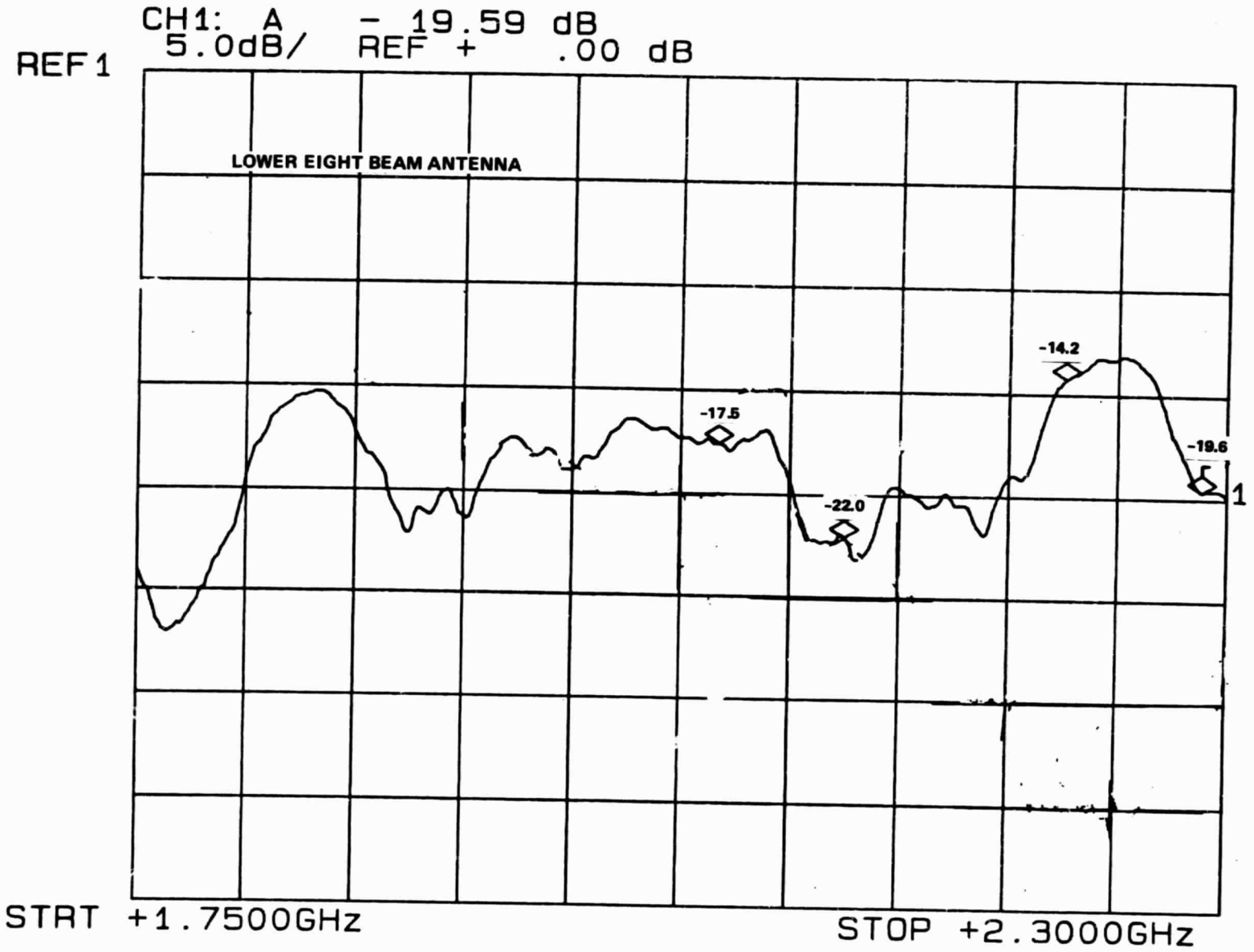


RETURN LOSS – BEAM 3

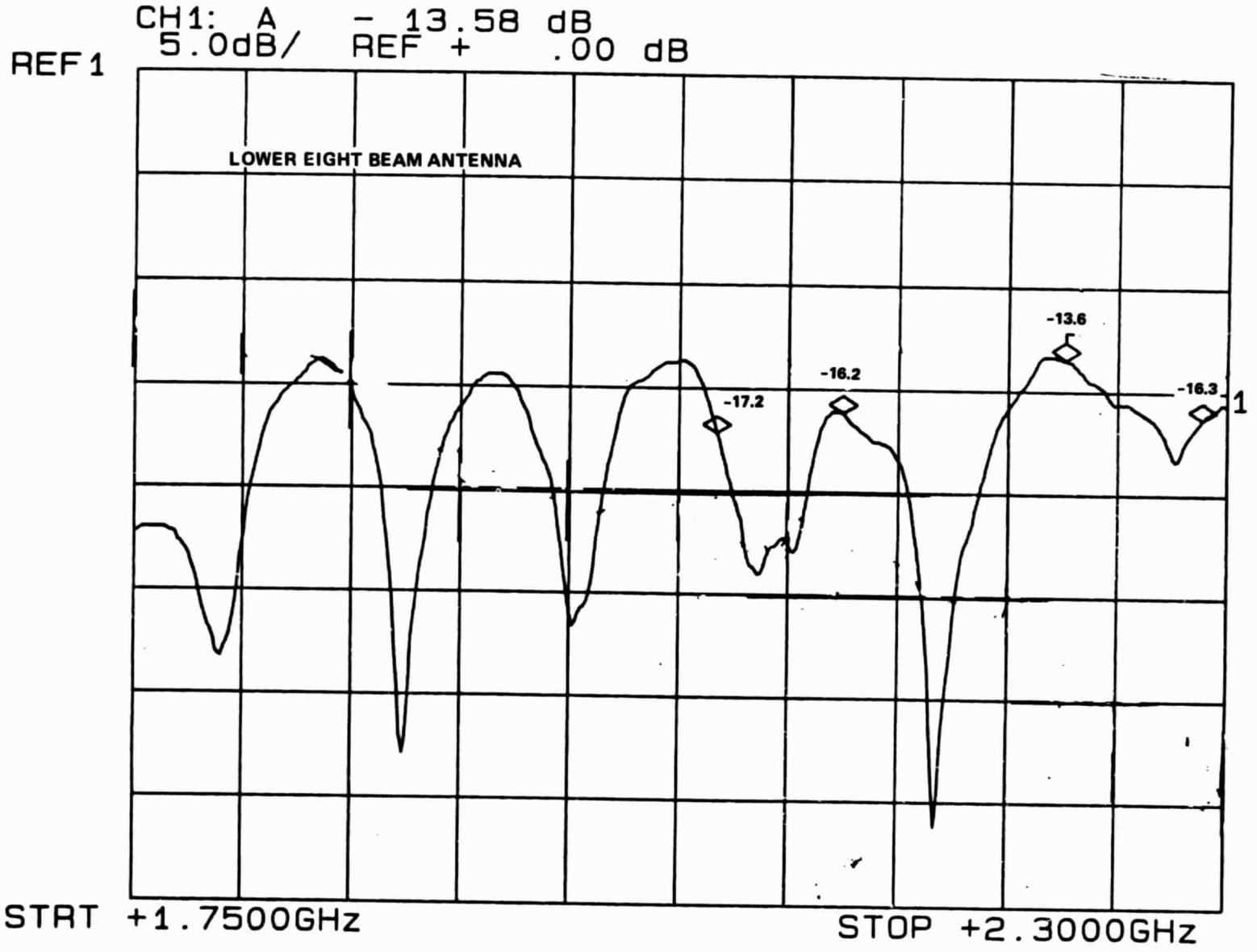


RETURN LOSS – BEAM 4

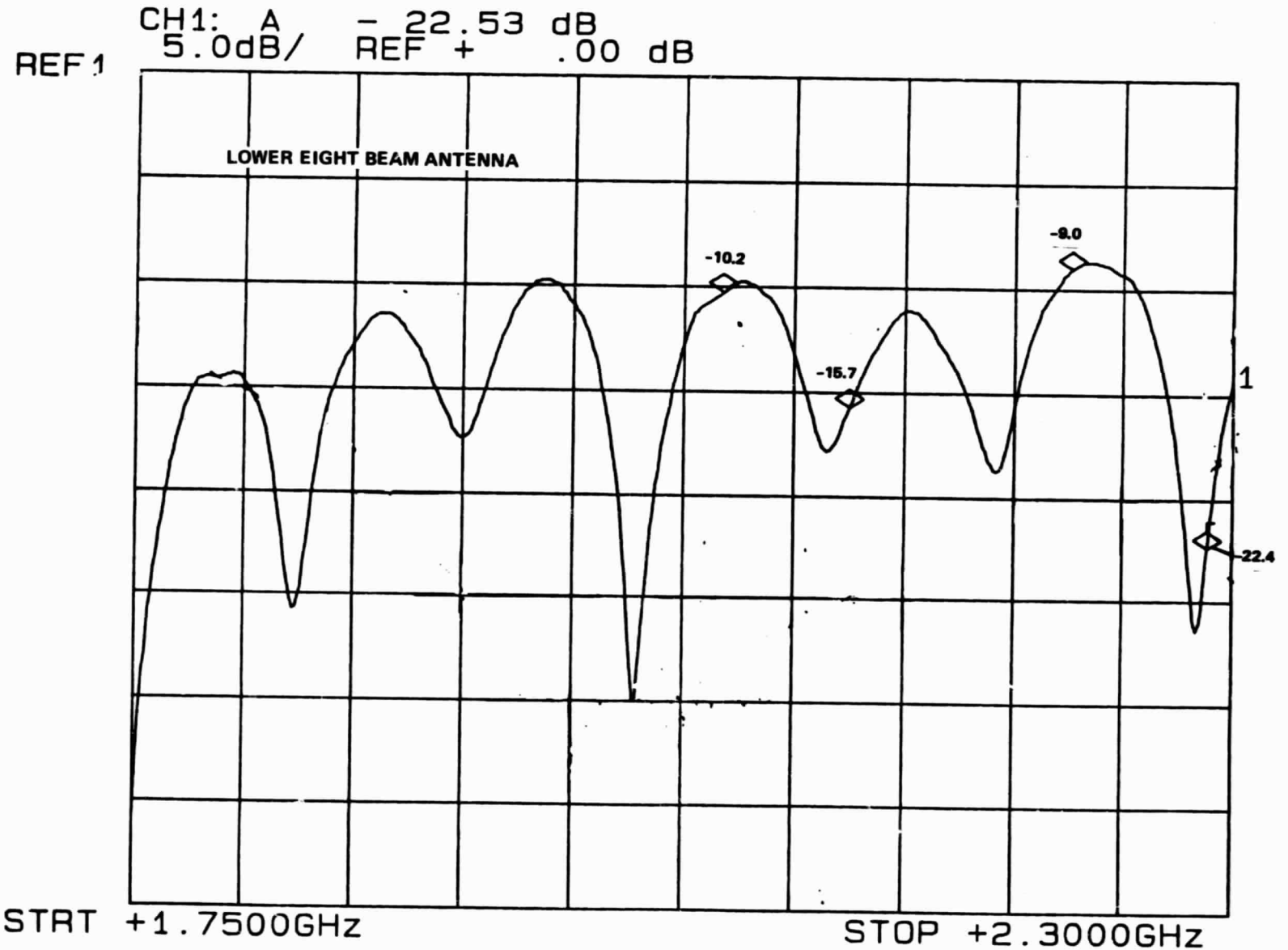

CH1: A – 9.40 dB
REF 1 5.0dB/ REF + .00 dB
LOWER EIGHT BEAM ANTENNA
-9.4
-9.0
-15.6
-23.6
1
START +1.7500GHz
RETURN LOSS – BEAM 5
STOP +2.3000GHz



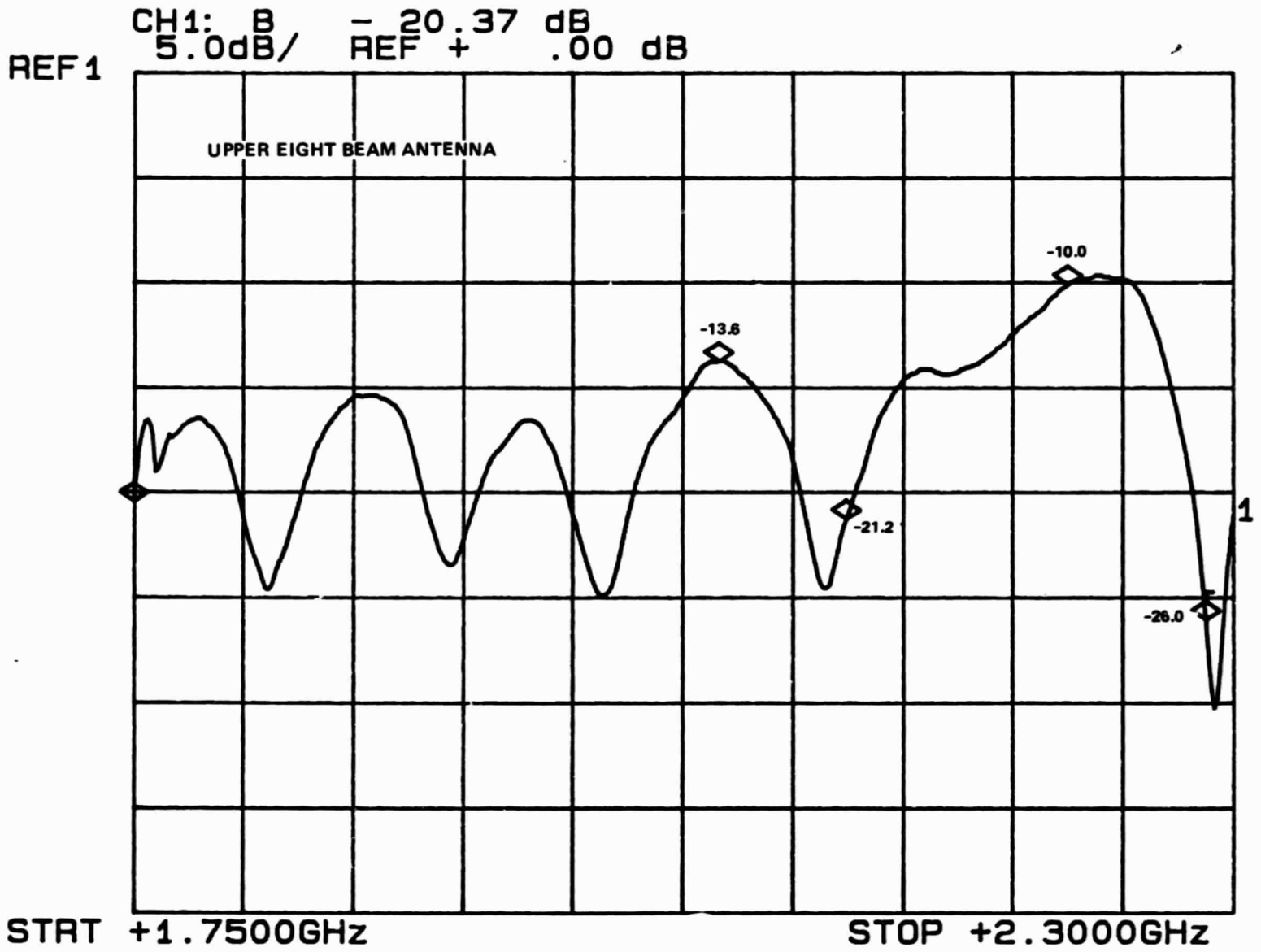
RETURN LOSS – BEAM 6



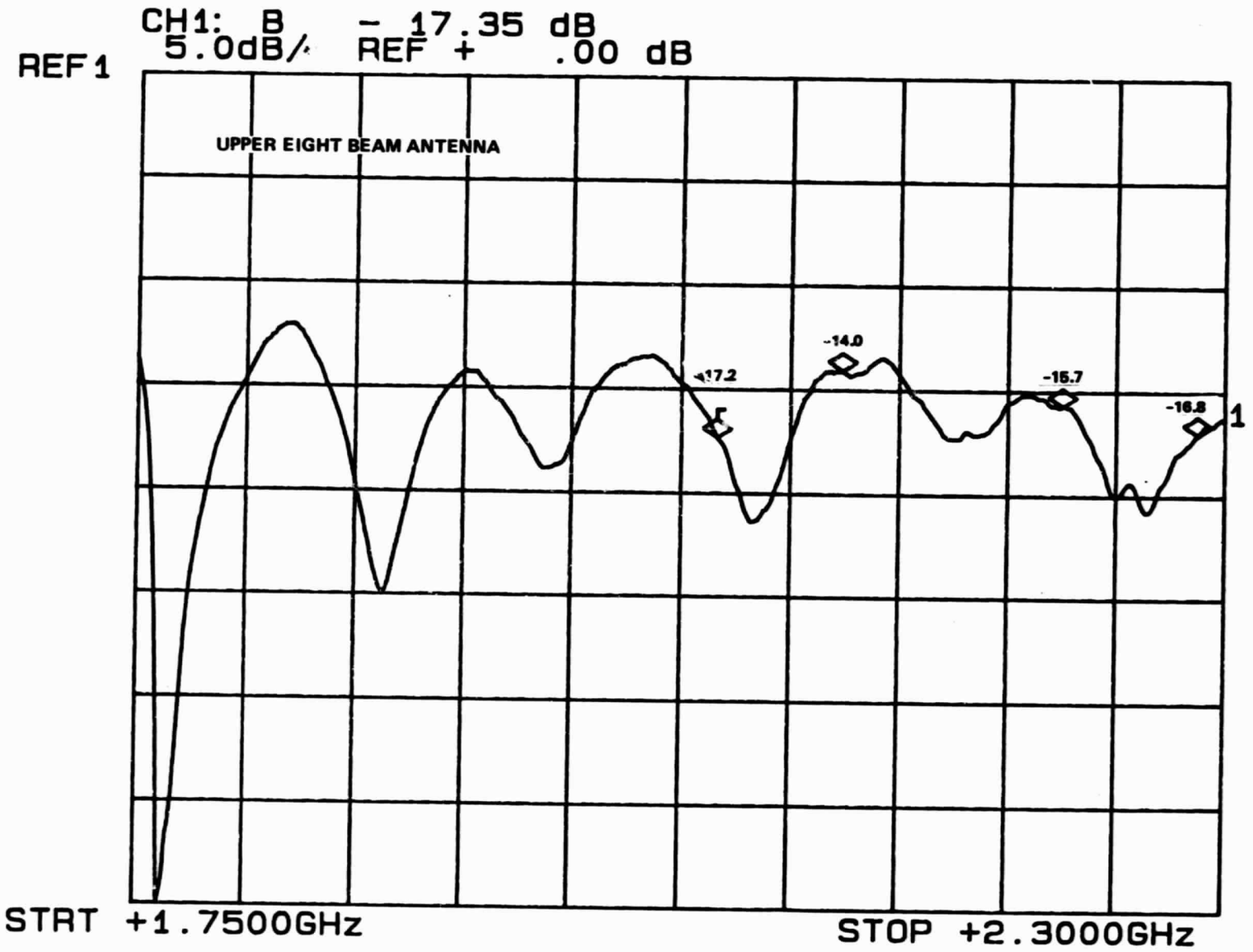
RETURN LOSS – BEAM 7



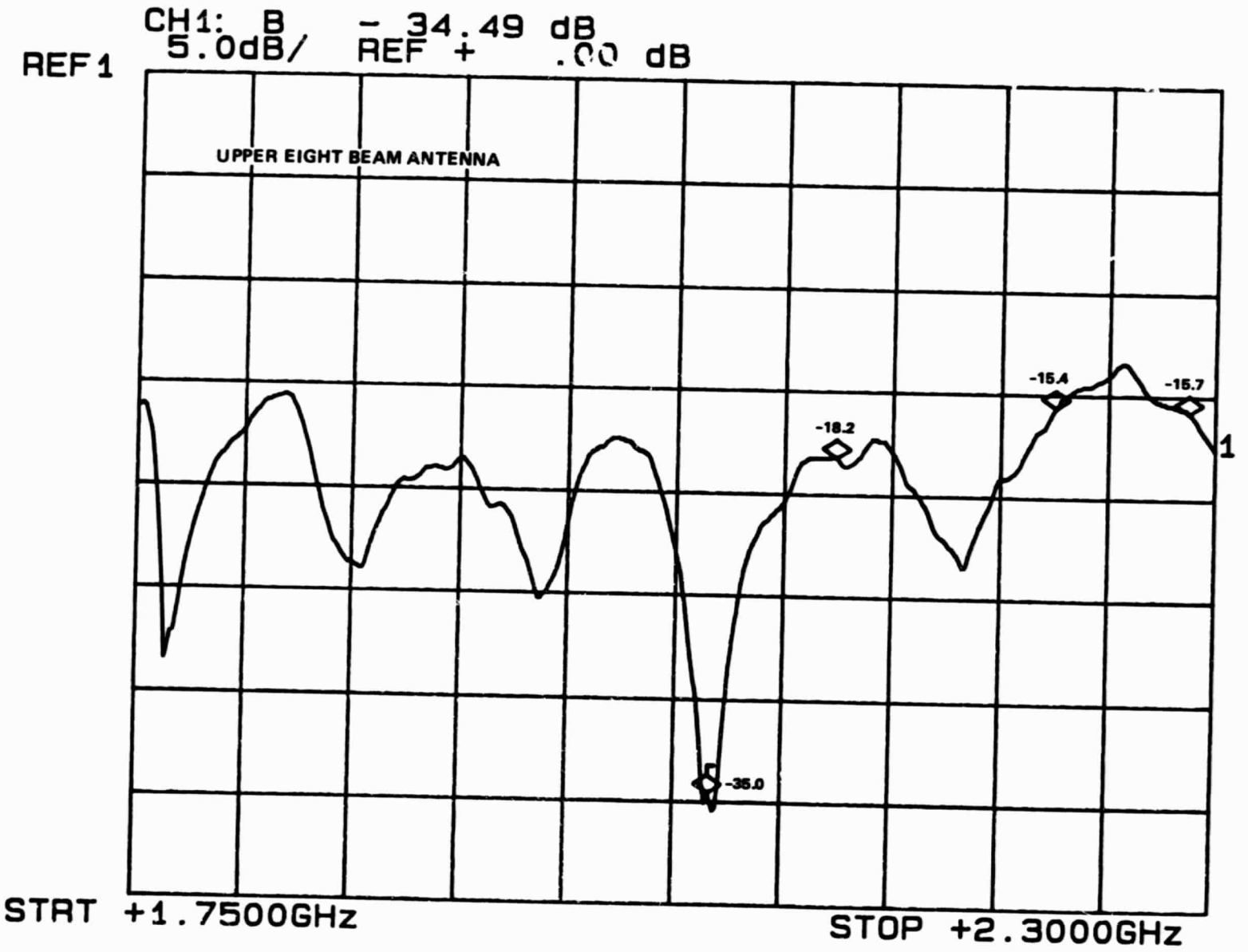
RETURN LOSS – BEAM 8



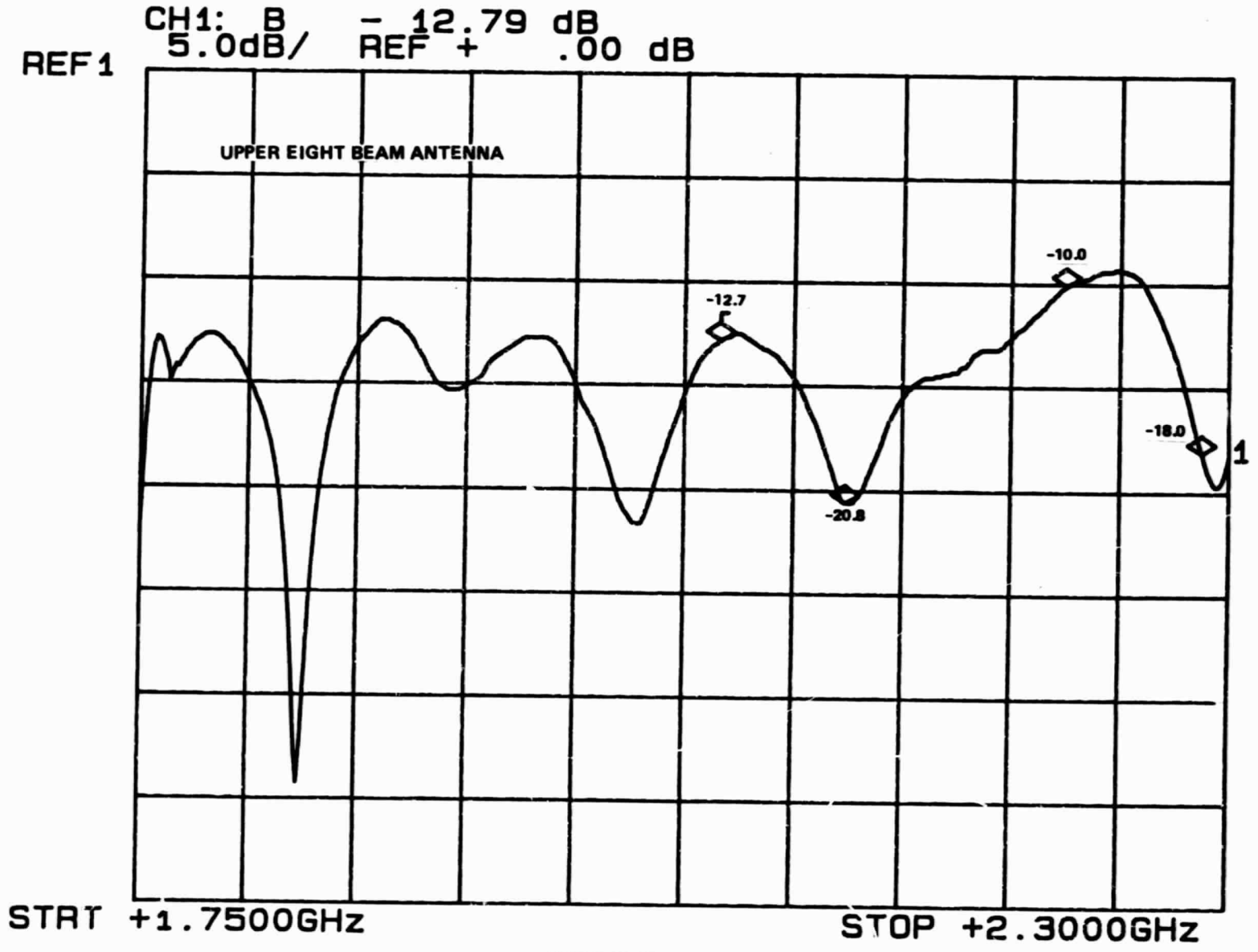
RETURN LOSS – BEAM 1



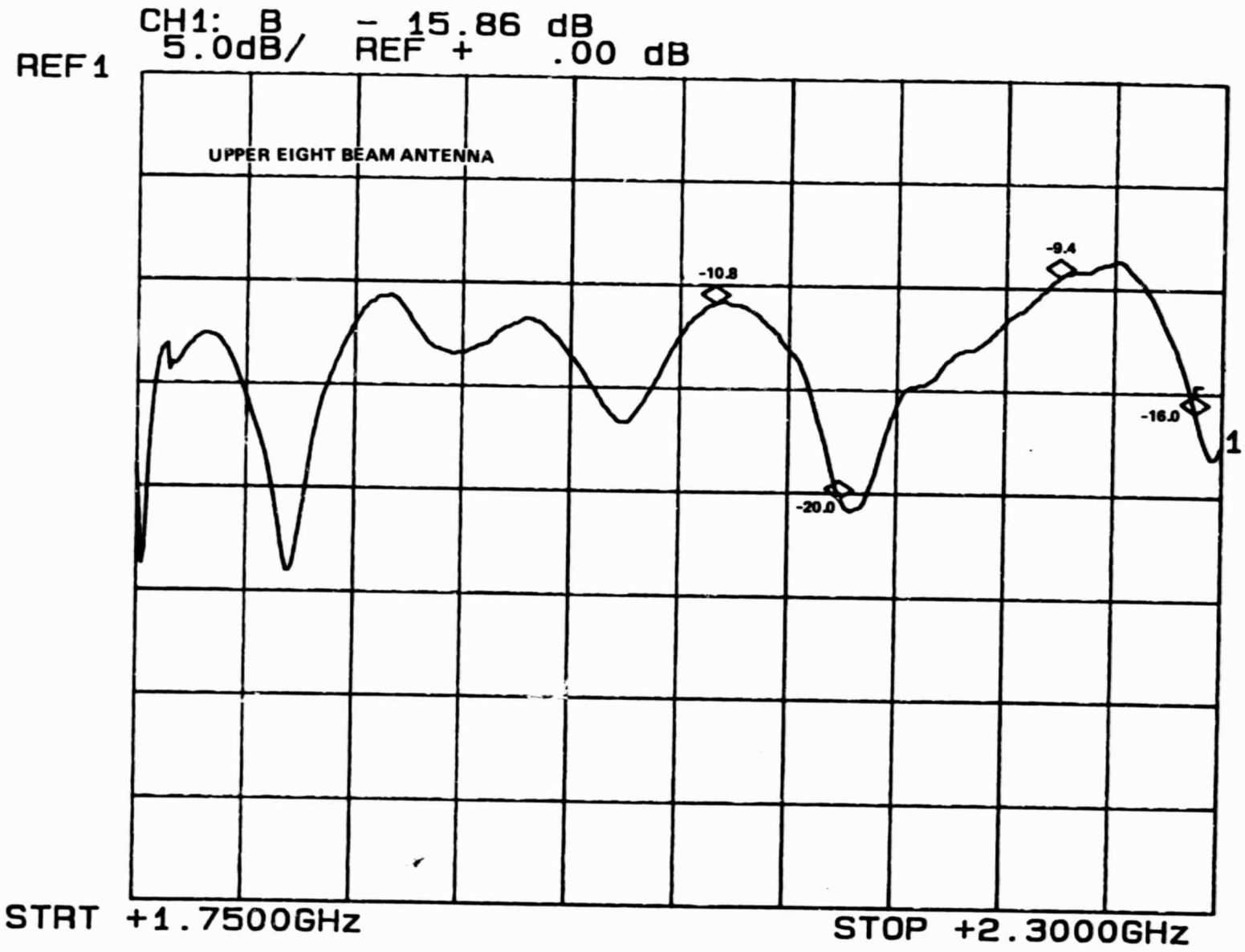
RETURN LOSS – BEAM 2



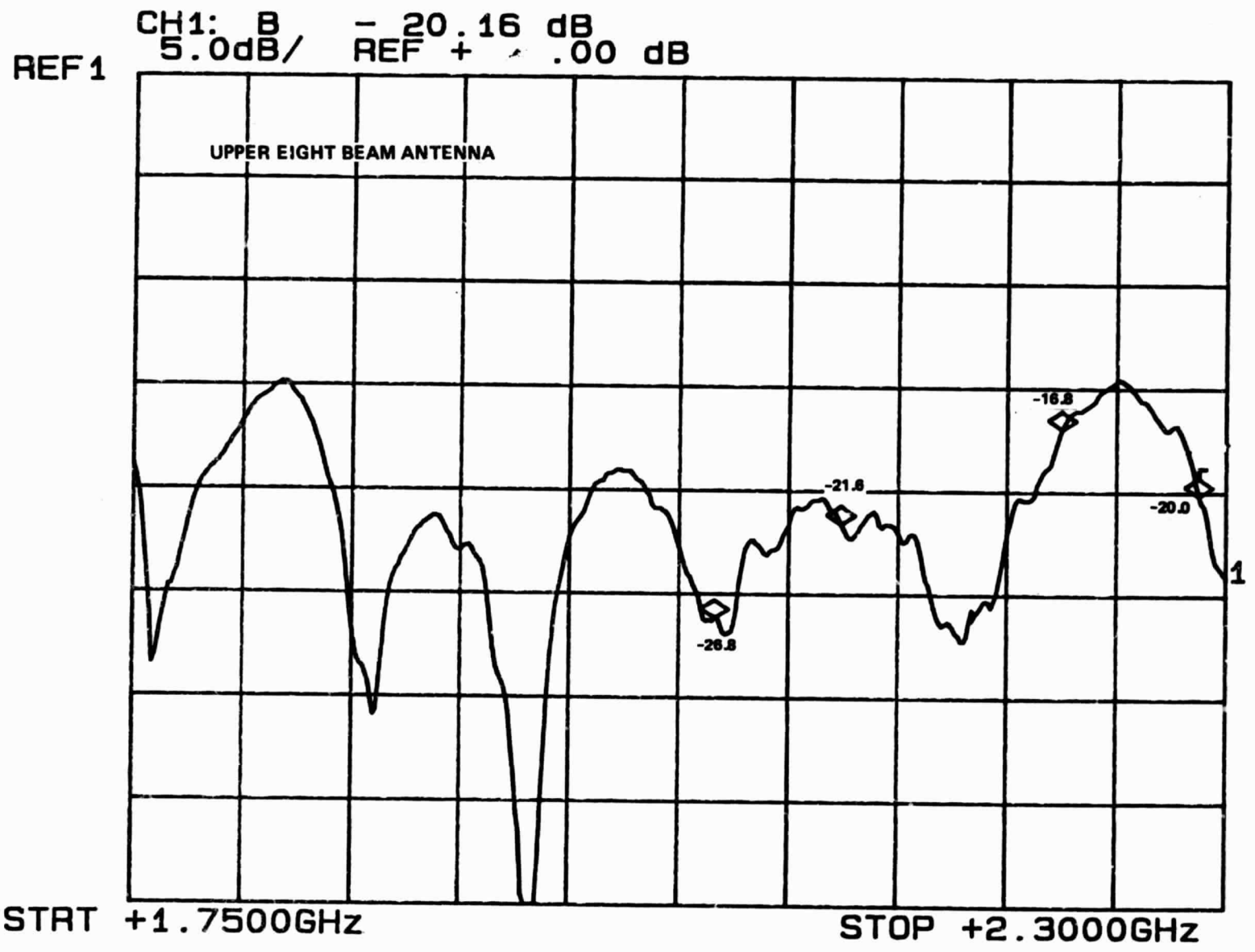
RETURN LOSS – BEAM 3



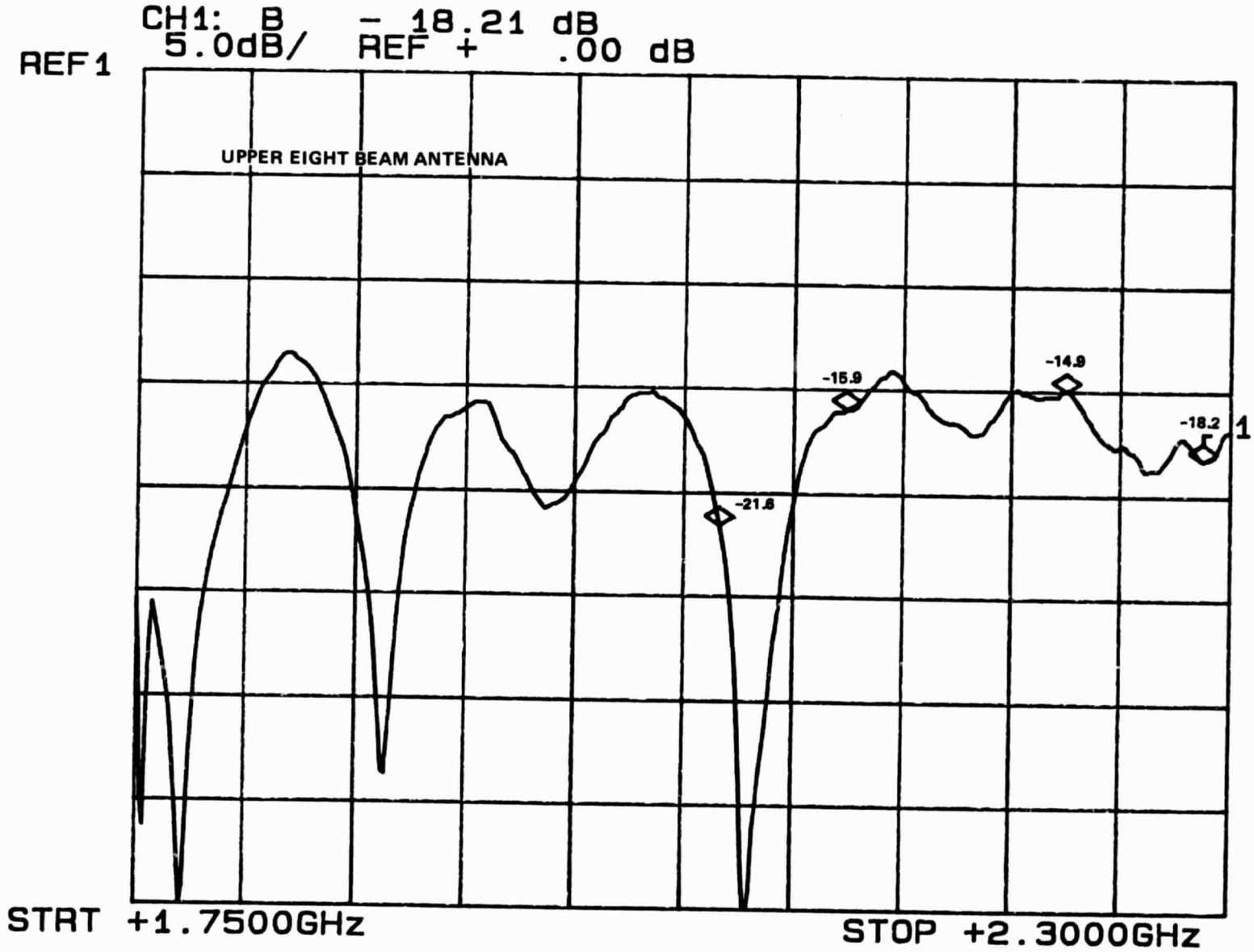
RETURN LOSS – BEAM 4



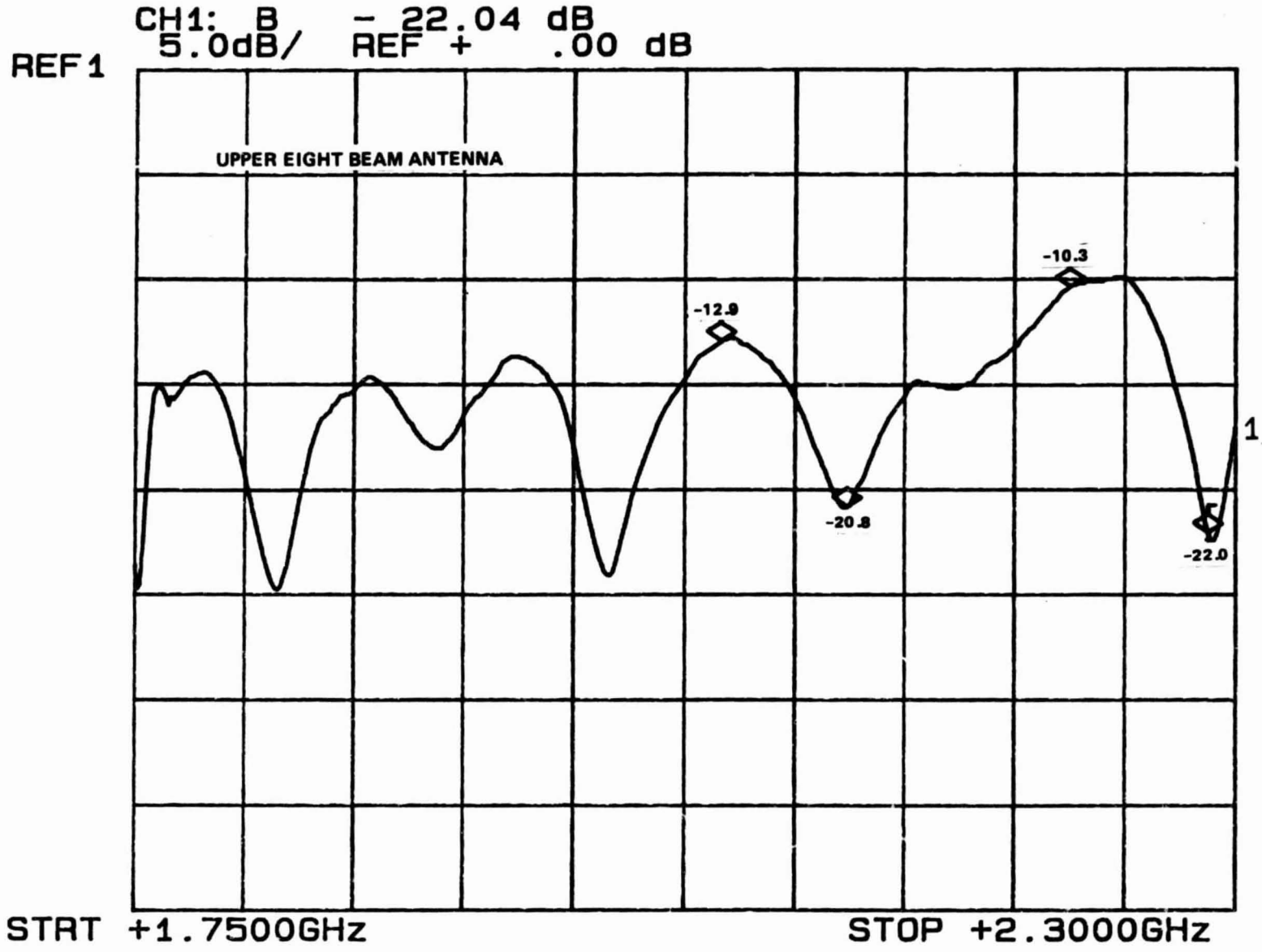
RETURN LOSS – BEAM 5



RETURN LOSS – BEAM 6

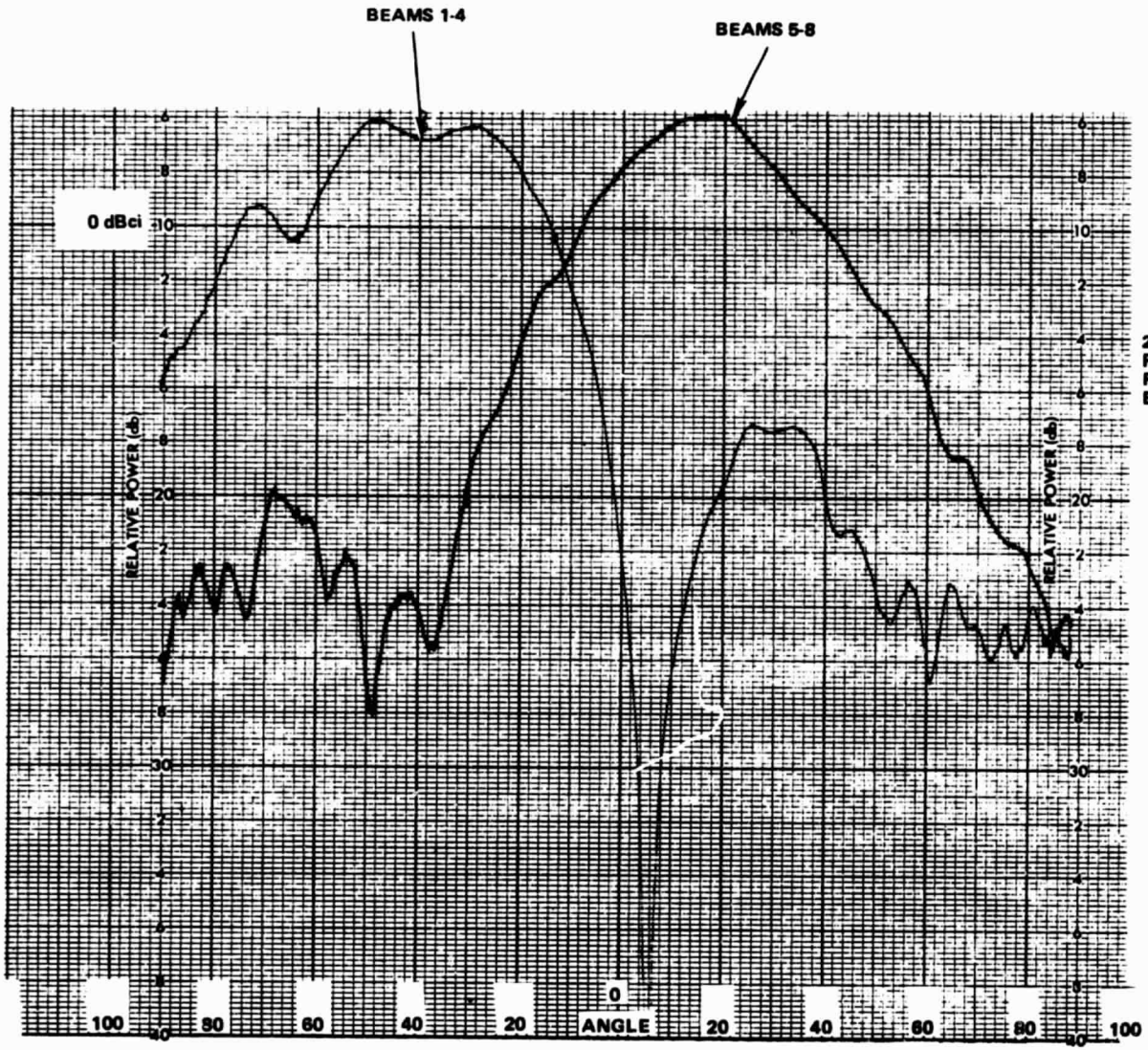


RETURN LOSS – BEAM 7



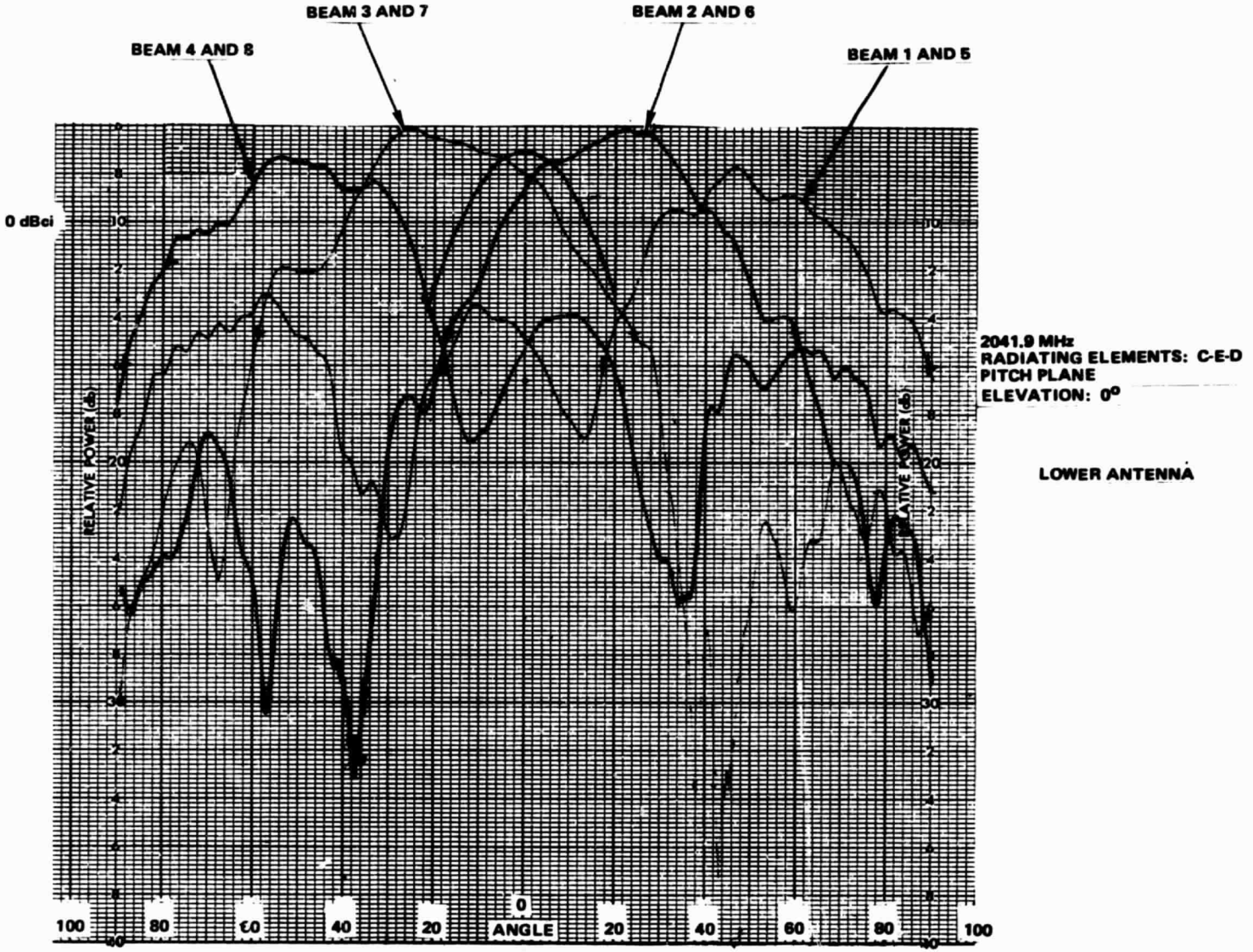
RETURN LOSS – BEAM 8

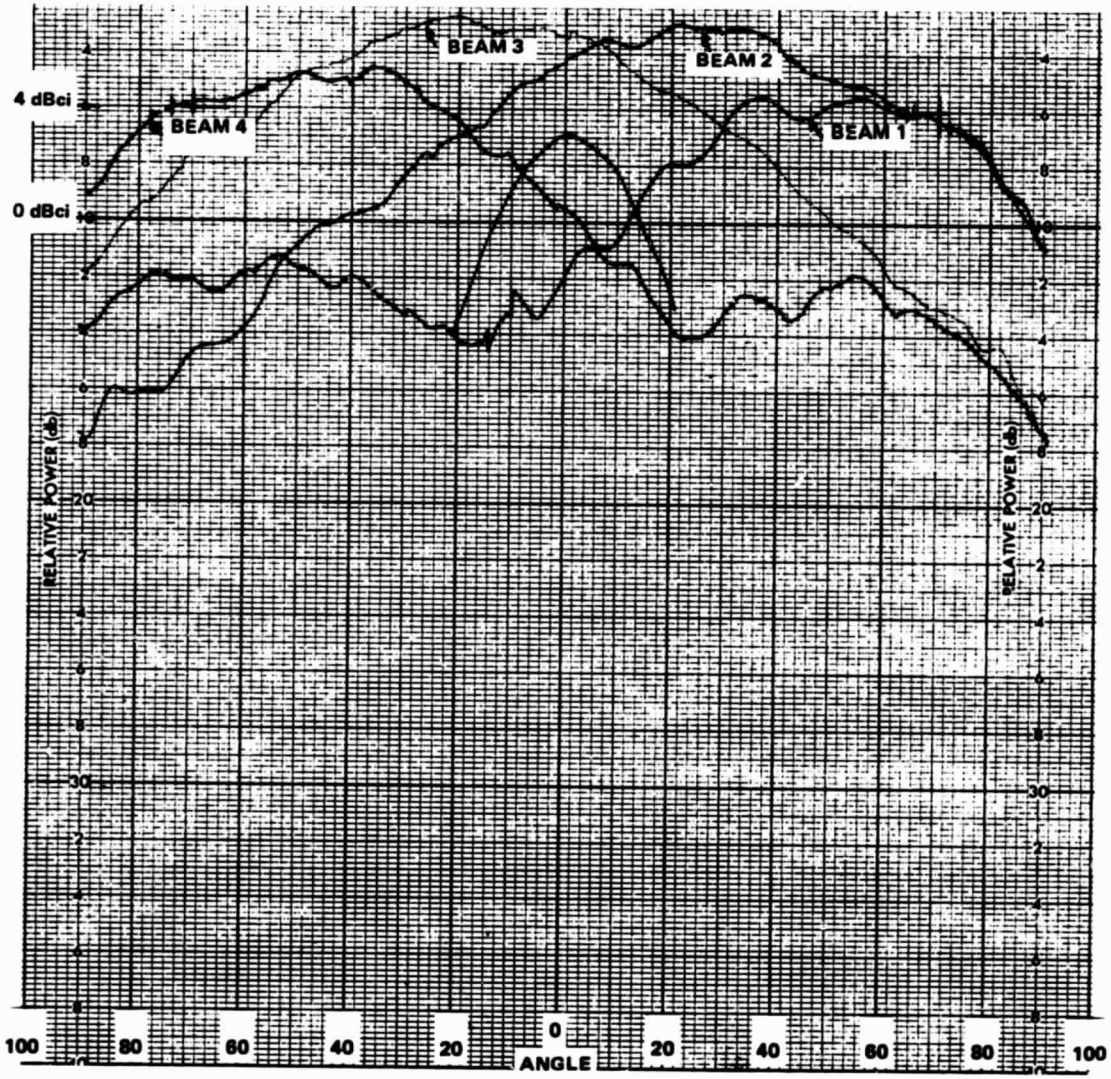
8. GAIN PATTERNS



2041.9 MHz
RADIATING ELEMENTS: A-E-B
ROLL PLANE
ELEVATION: 0°

LOWER ANTENNA

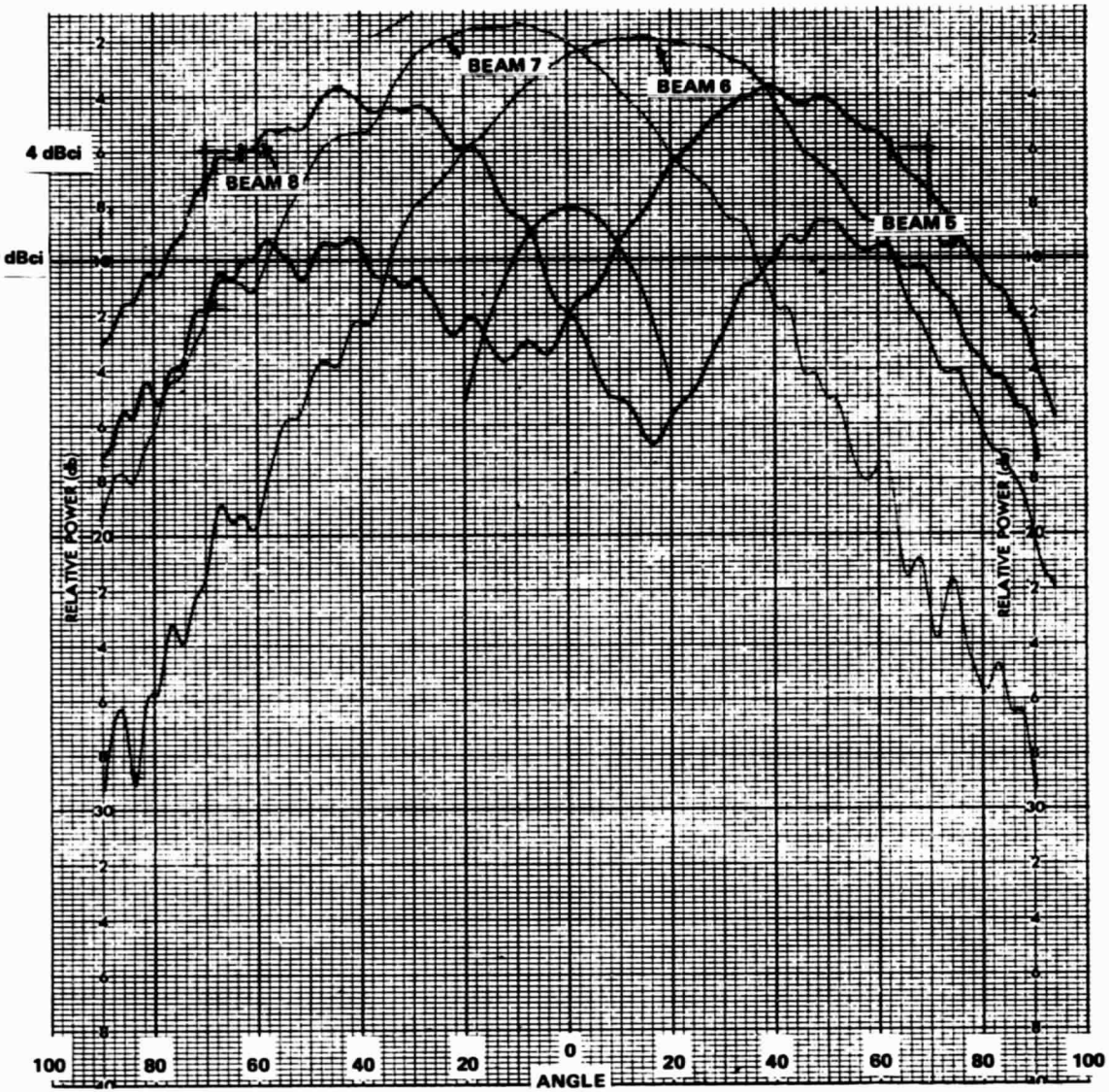

BEAM 3 AND 7
BEAM 2 AND 6
BEAM 4 AND 8
BEAM 1 AND 5
0 dBci
RELATIVE POWER (dB)
RELATIVE POWER (dB)
2041.9 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°
LOWER ANTENNA
100
80
60
40
20
0
ANGLE
20
40
60
80
100



2041.9 MHz
BEAMS 1 THRU 4 (PITCH)
ELEVATION: 45.3° DOWN

MEASURED USING
SCAN ANGLES
FROM 2150 MHz

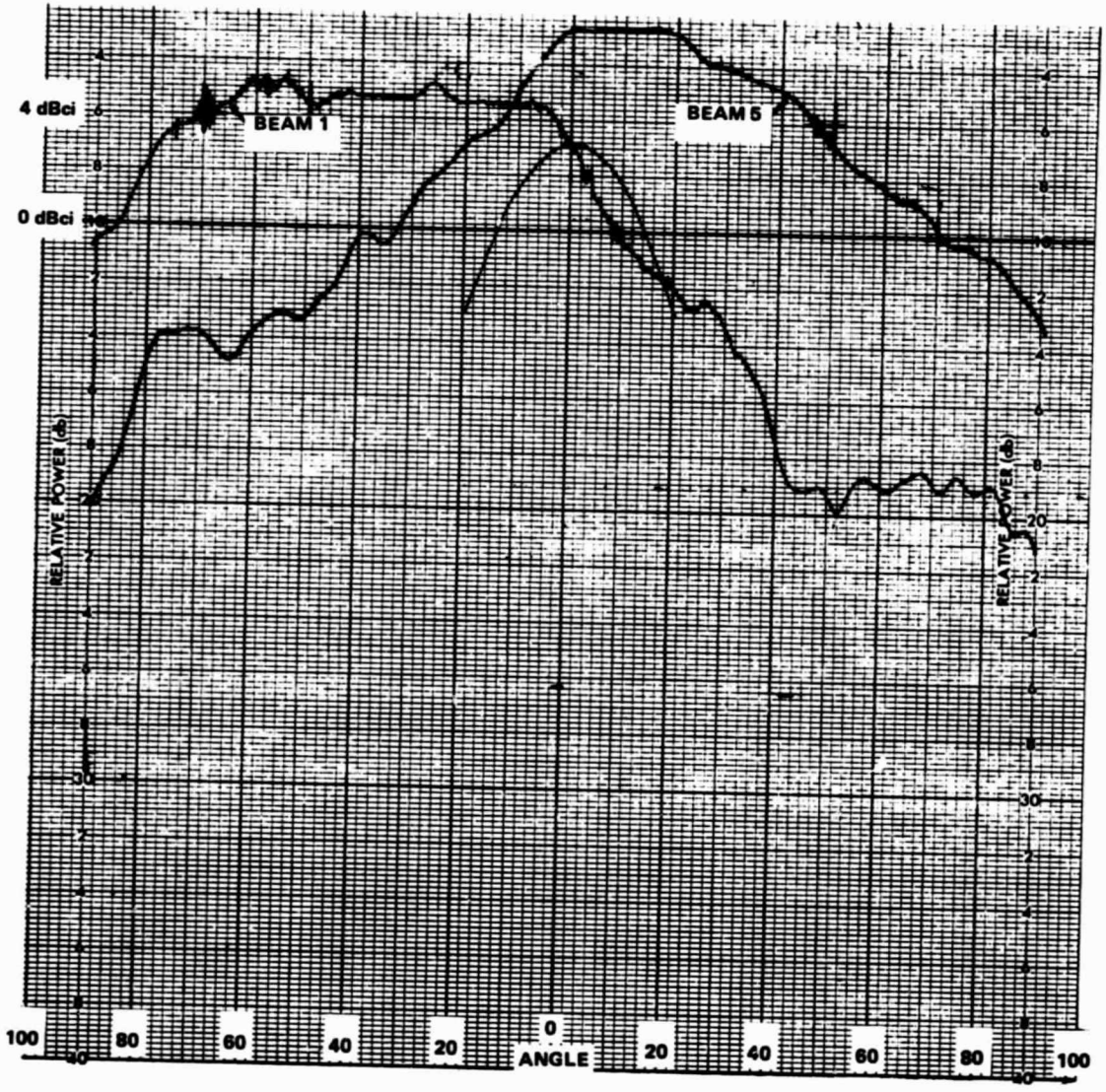
LOWER ANTENNA



2041.9 MHz
BEAMS 5 THRU 8 (PITCH)
ELEVATION: 5.0° UP

MEASURED USING
SCAN ANGLES
FROM 2150 MHz

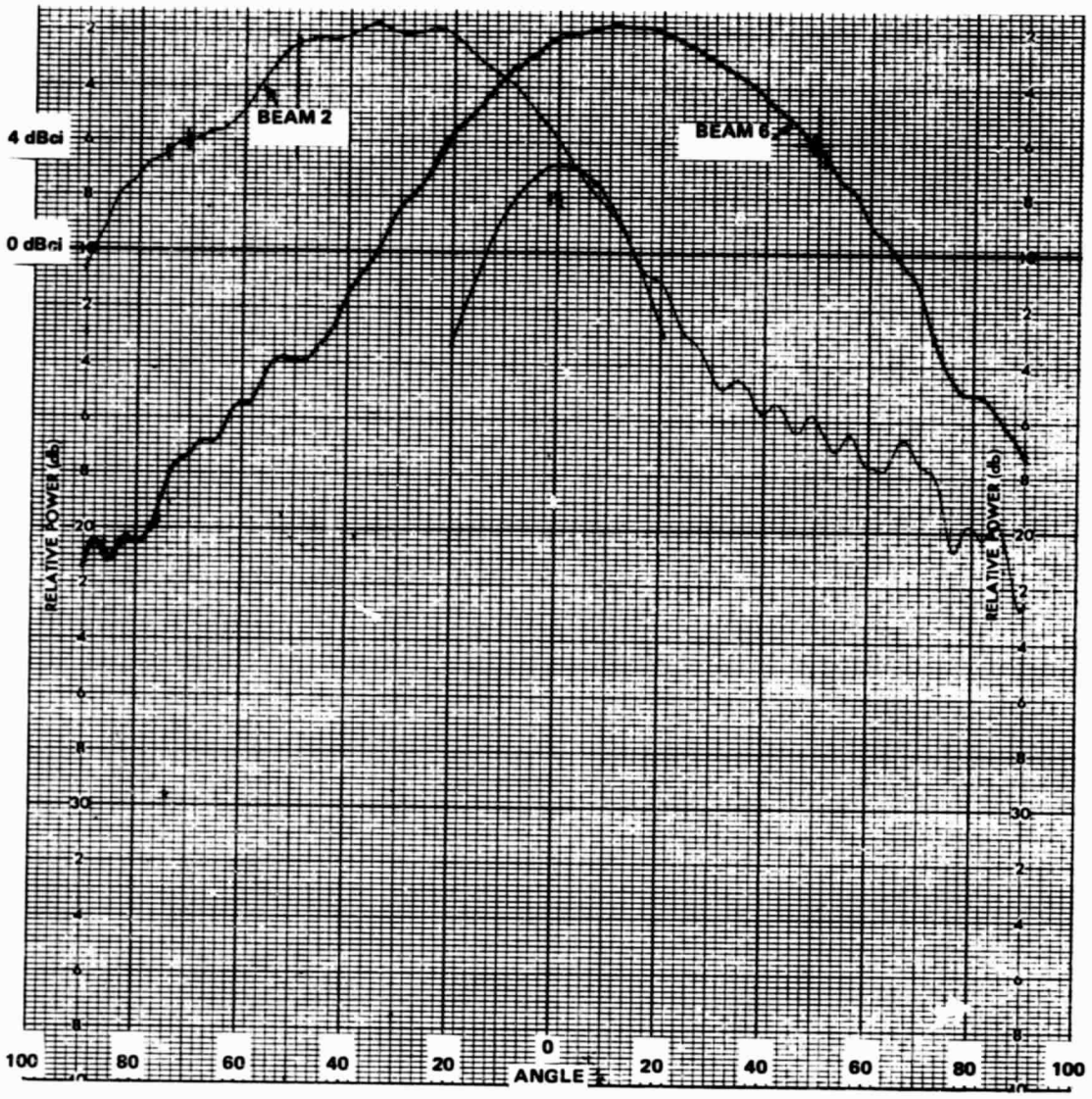
LOWER ANTENNA



2041.9 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 46.4° DOWN

MEASURED USING
SCAN ANGLES
FROM 2150 MHz

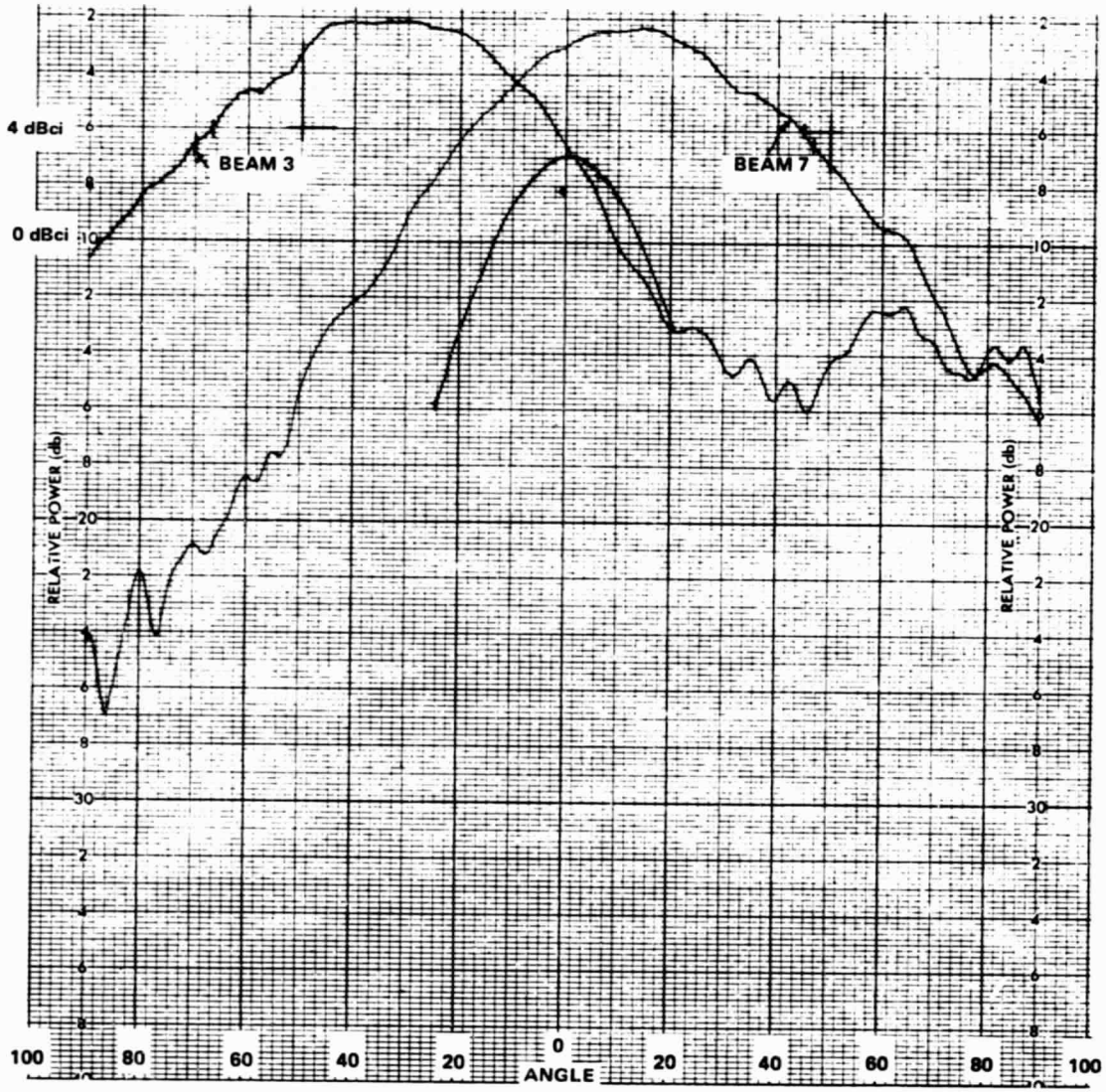
LOWER ANTENNA



2041.9 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 13.5° DOWN

MEASURED USING
SCAN ANGLES
FROM 2150 MHz

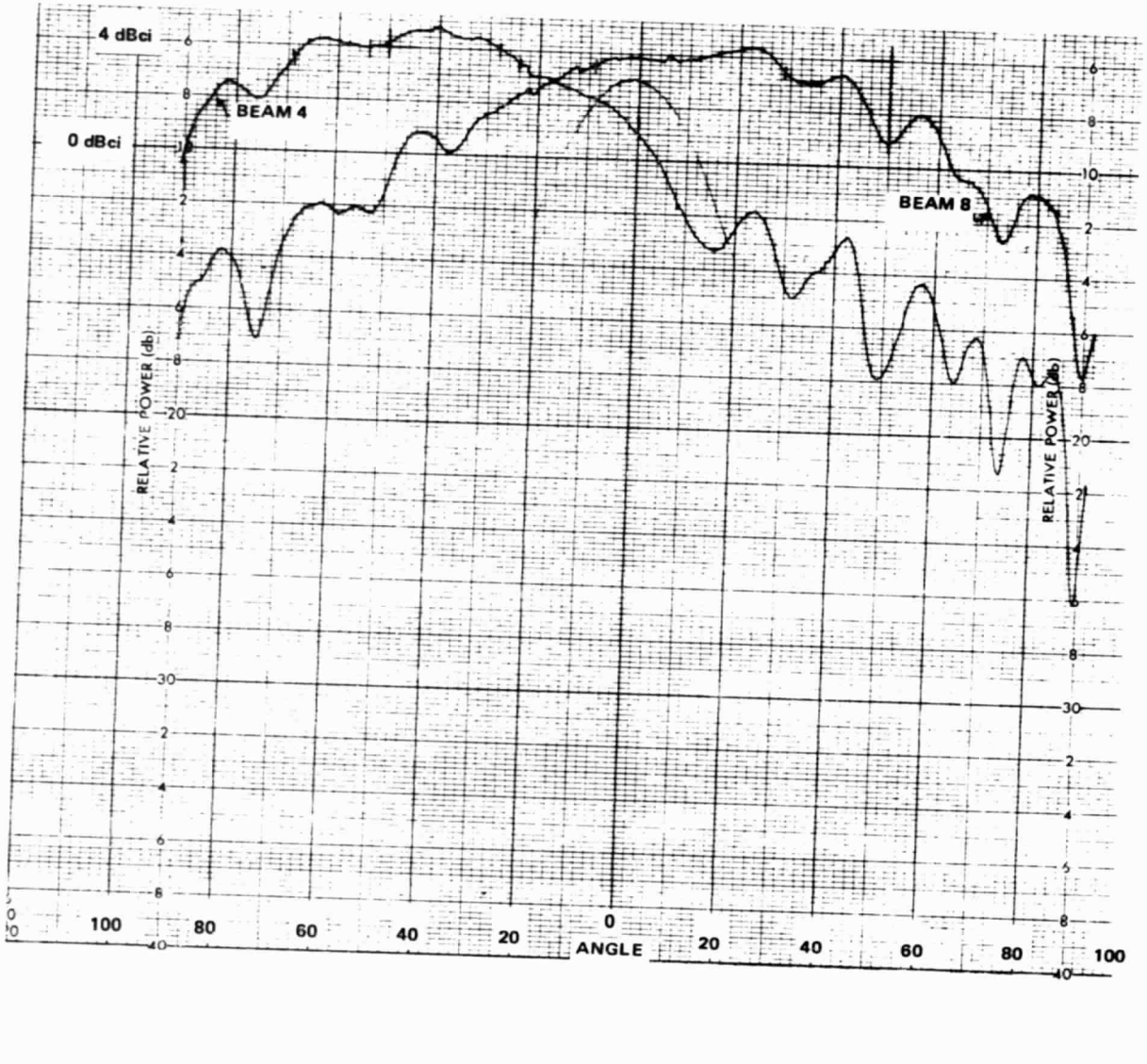
LOWER ANTENNA



2041.9 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 12.5° UP

MEASURED USING SCAN ANGLES FROM 2150 MHz

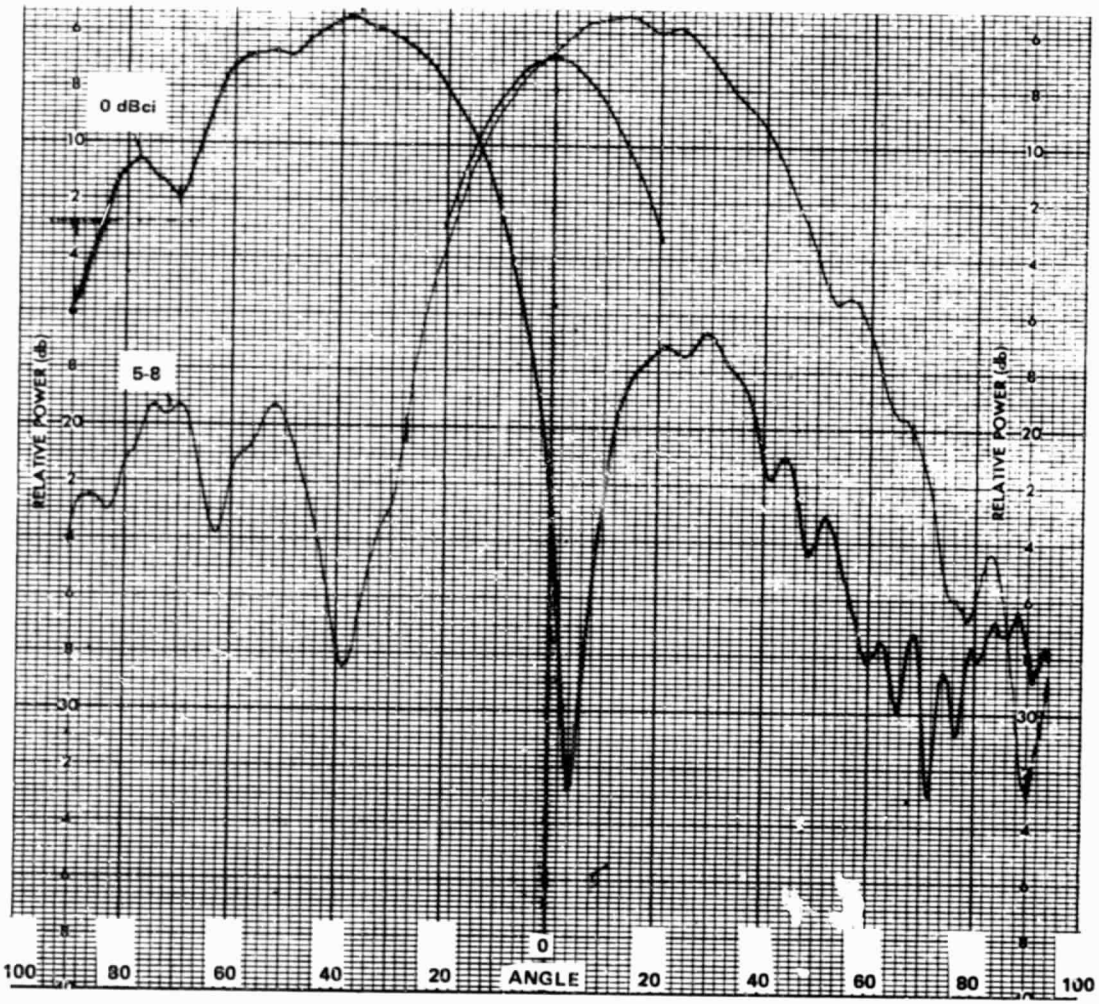
LOWER ANTENNA



2041.9 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 52.0° UP

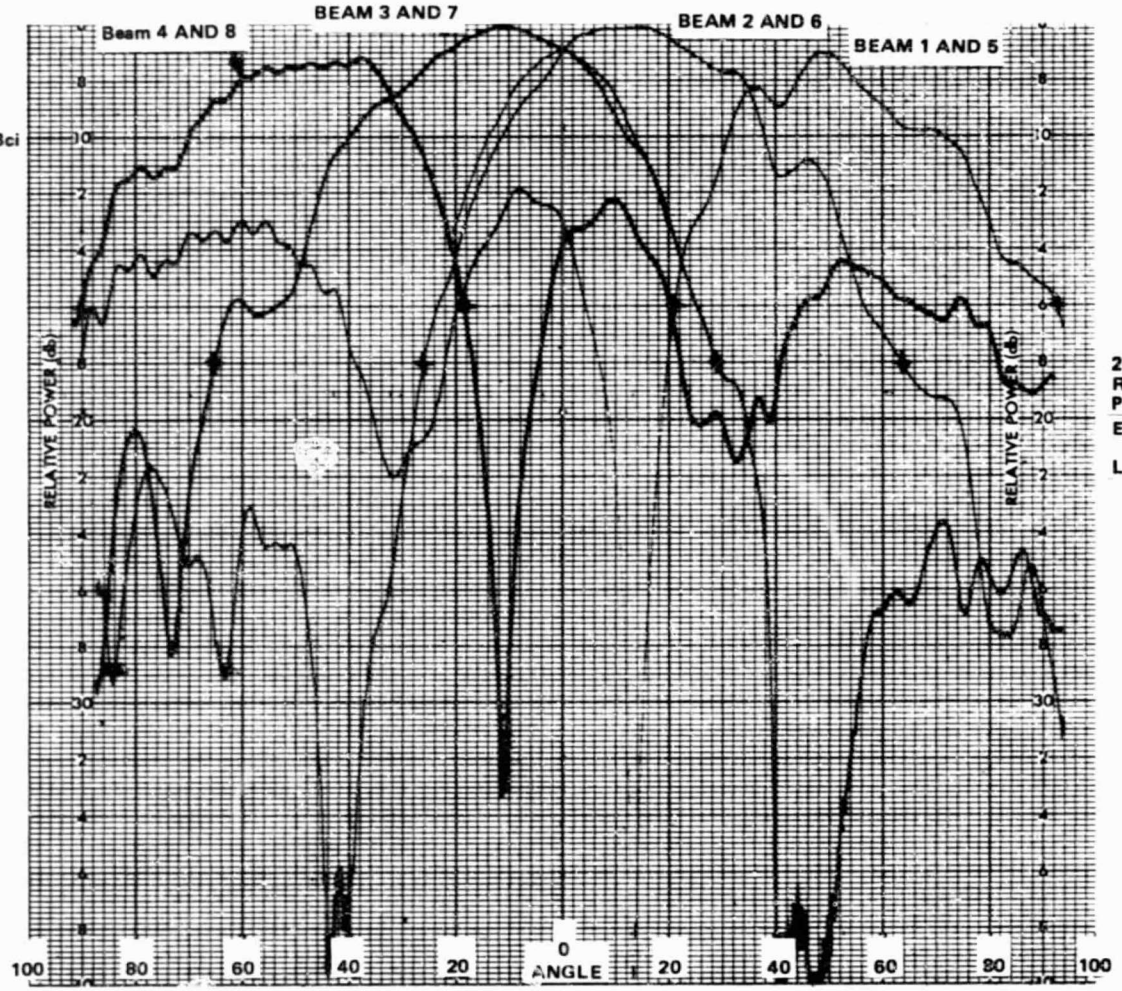
MEASURED USING
SCAN ANGLES
FROM 2150 MHz

LOWER ANTENNA



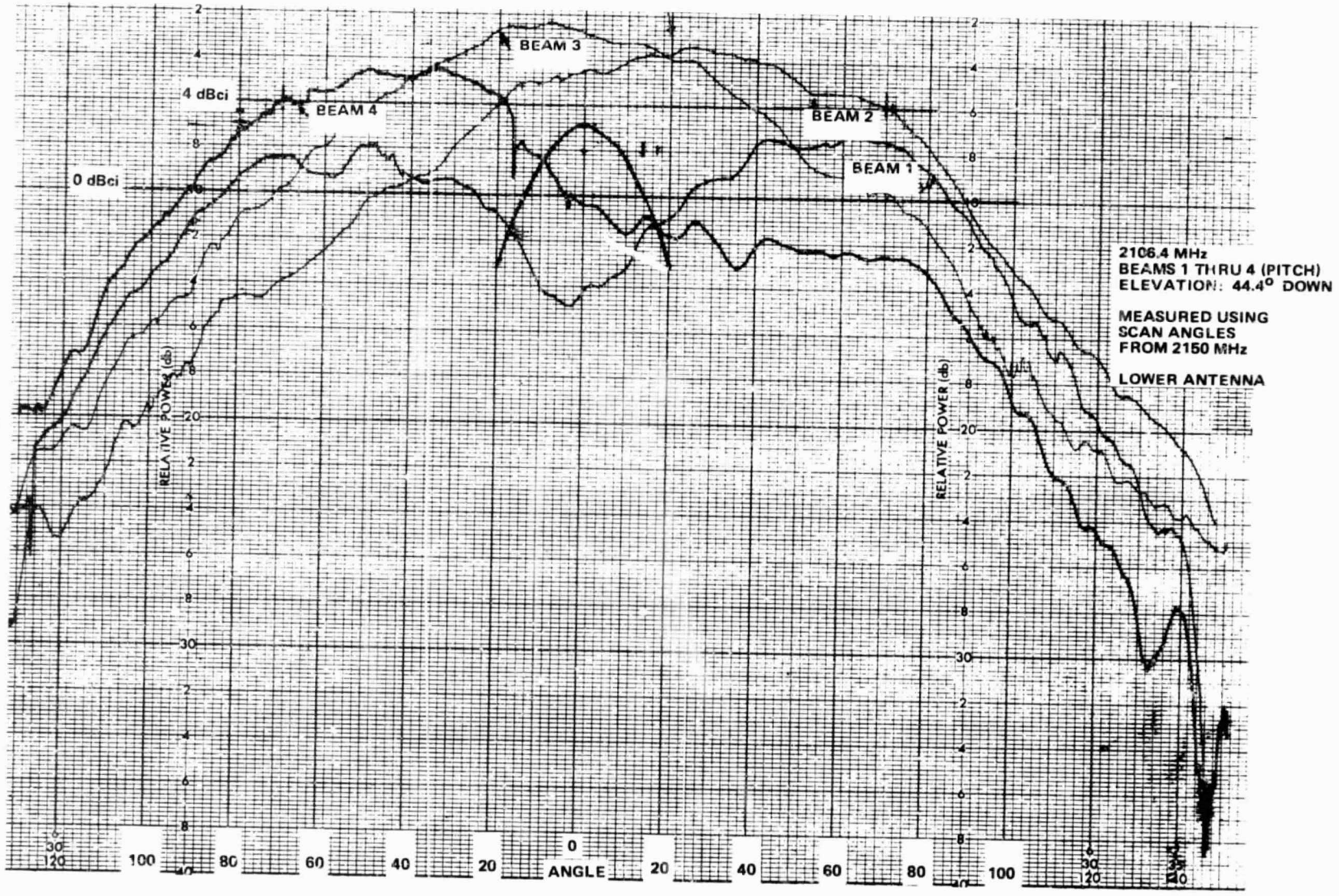
2106.4 MHz
RADIATING ELEMENTS: A-E-B
ROLL PLANE
ELEVATION: 0°

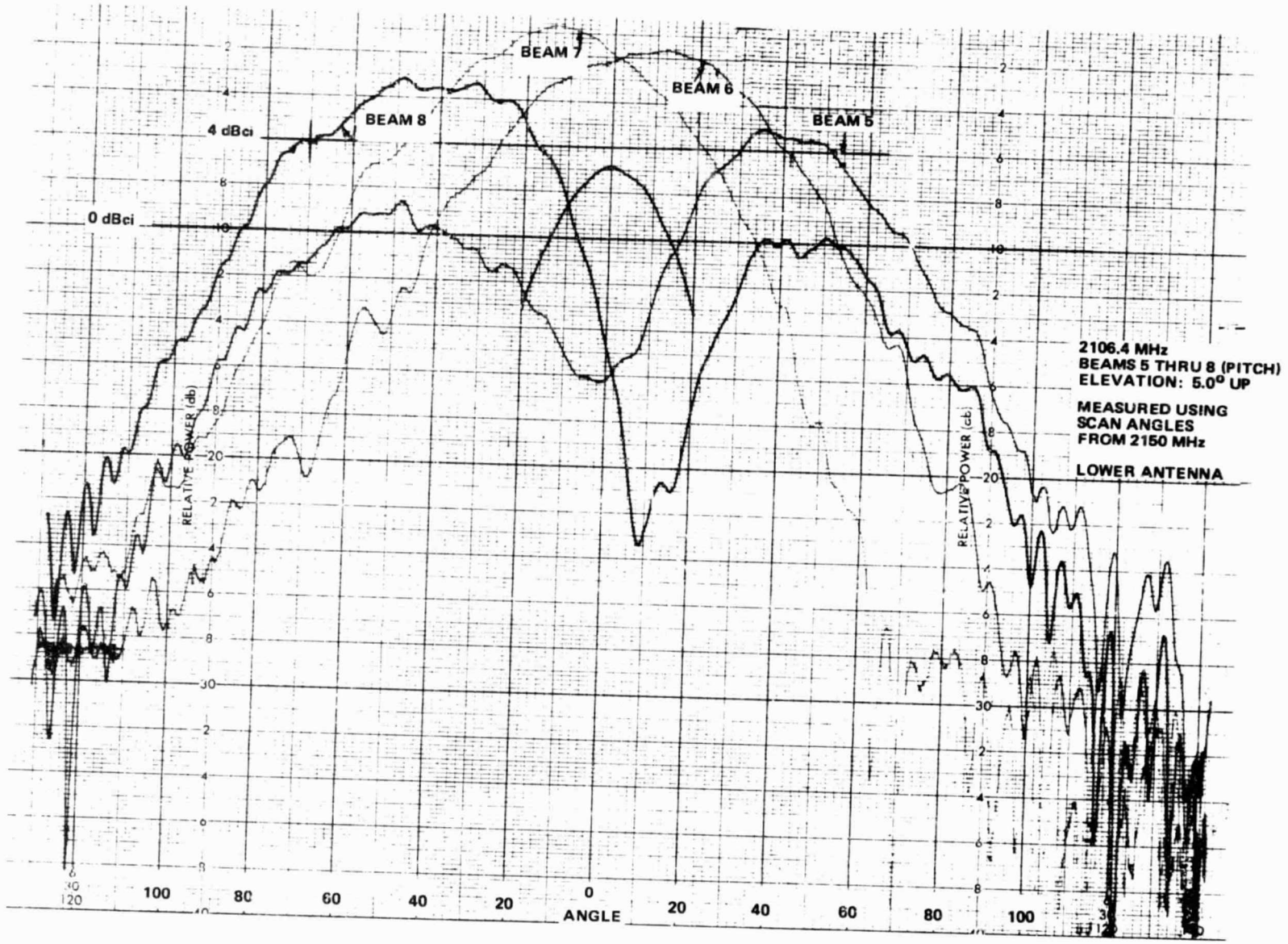
LOWER ANTENNA

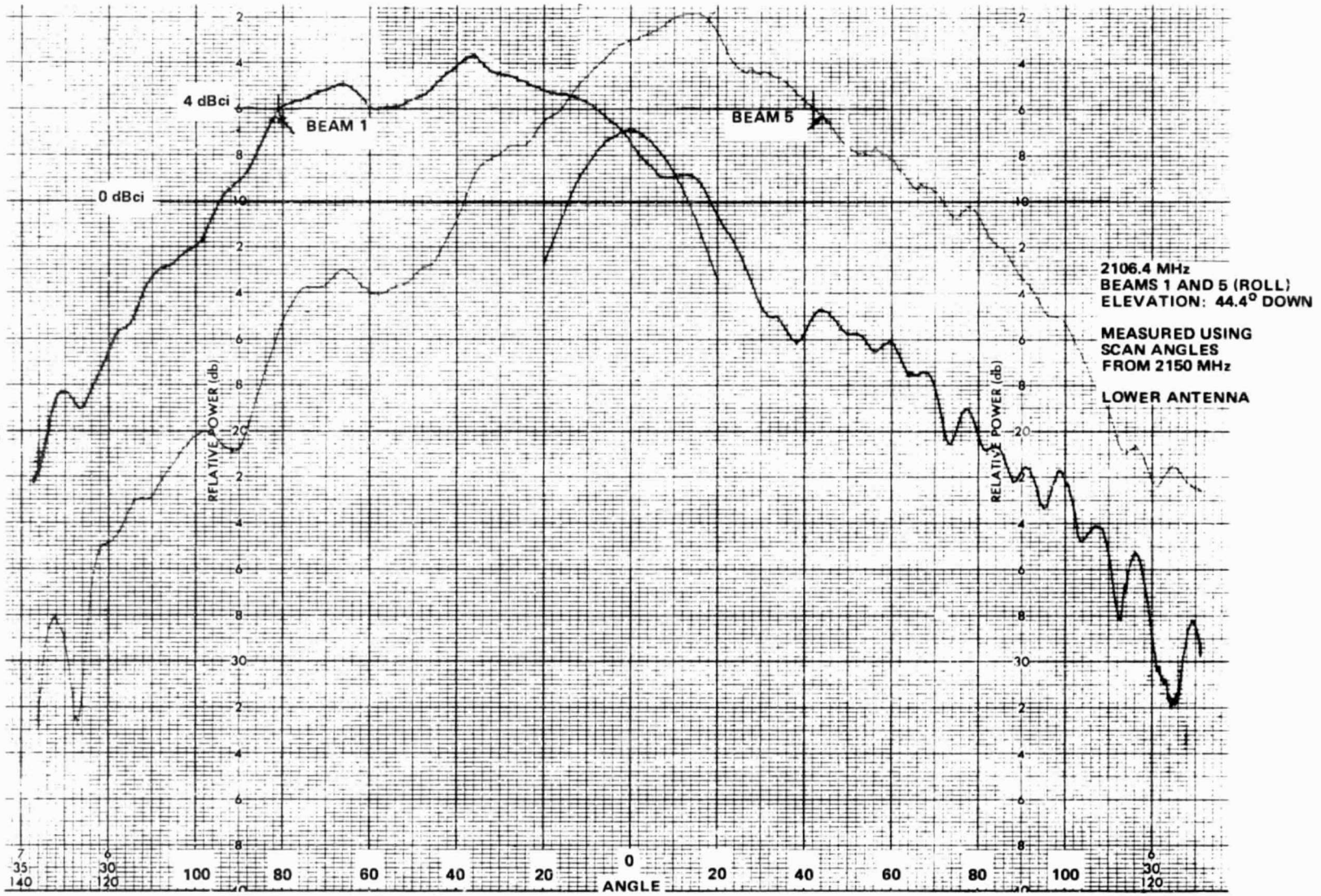


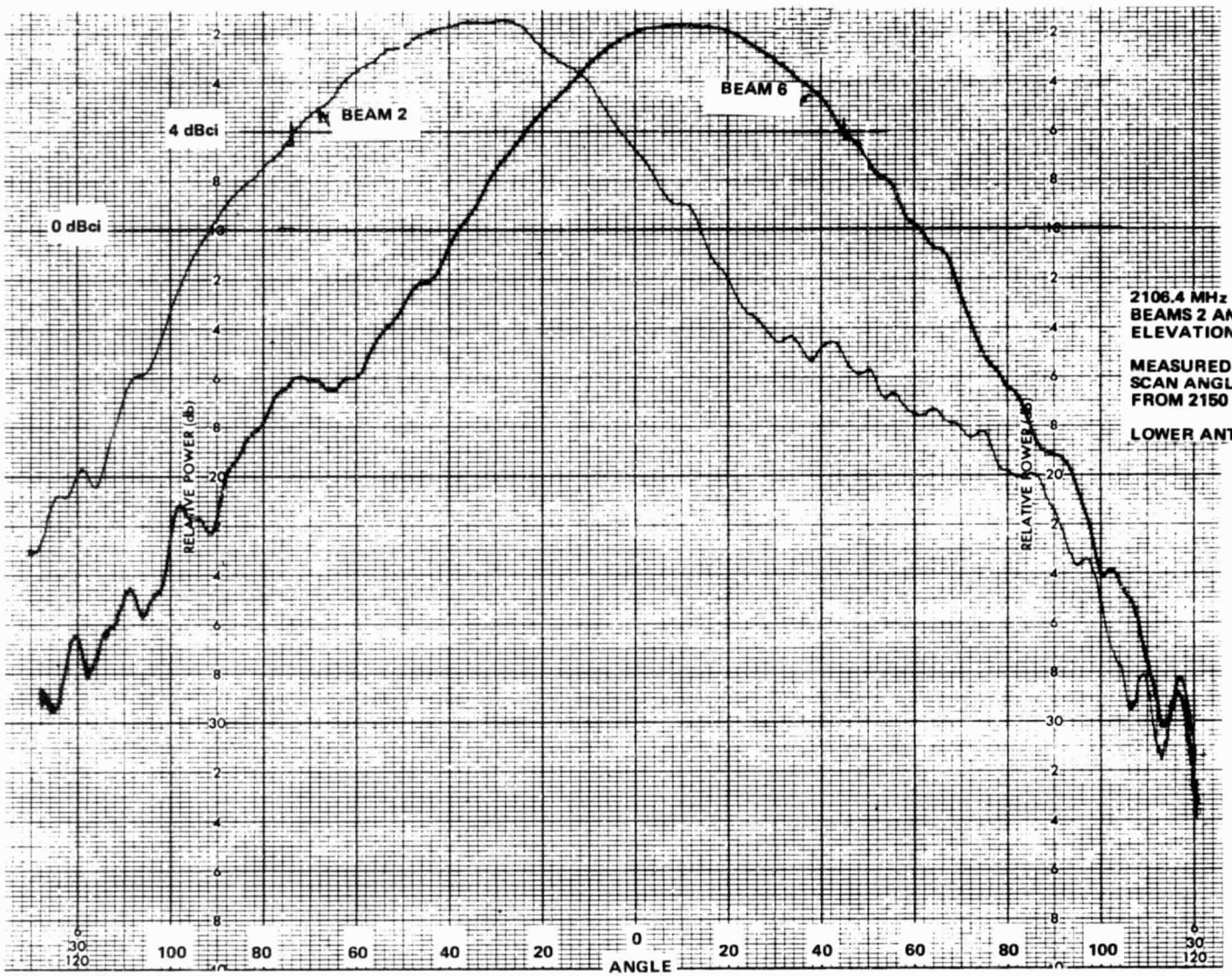
2106.4 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°

LOWER ANTENNA


BEAM 3
4 dBci
BEAM 4
BEAM 2
BEAM 1
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
2106.4 MHz
BEAMS 1 THRU 4 (PITCH)
ELEVATION: 44.4° DOWN
MEASURED USING
SCAN ANGLES
FROM 2150 MHz
LOWER ANTENNA
100
80
60
40
20
0
ANGLE
20
40
60
80
100


BEAM 7
BEAM 6
BEAM 8
BEAM 5
4 dBci
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
2106.4 MHz
BEAMS 5 THRU 8 (PITCH)
ELEVATION: 5.0° UP
MEASURED USING
SCAN ANGLES
FROM 2150 MHz
LOWER ANTENNA

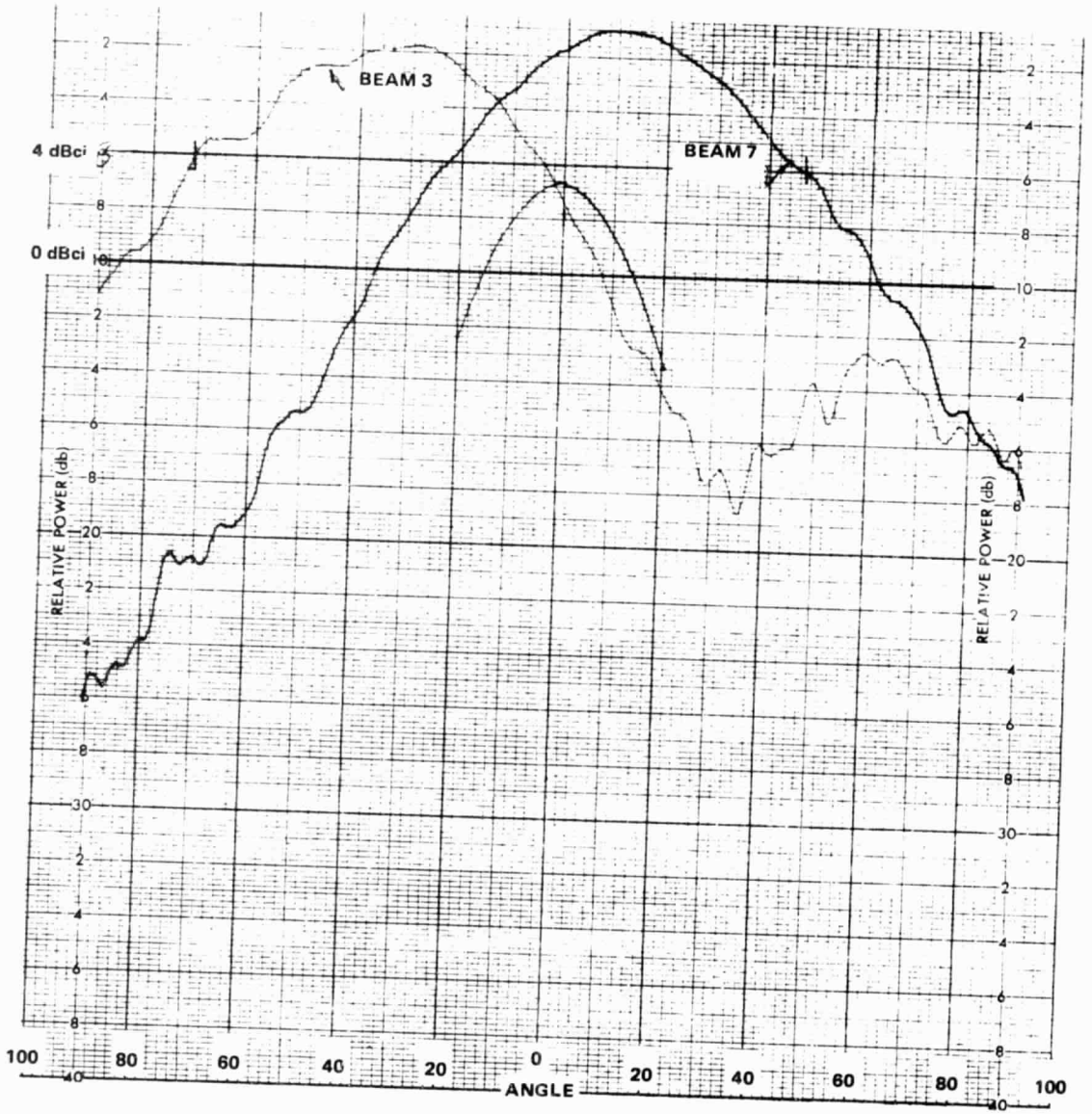

4 dBci
0 dBci
BEAM 1
BEAM 5
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
2106.4 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 44.4° DOWN
MEASURED USING
SCAN ANGLES
FROM 2150 MHz
LOWER ANTENNA



2106.4 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 13.5° DOWN

MEASURED USING
SCAN ANGLES
FROM 2150 MHz

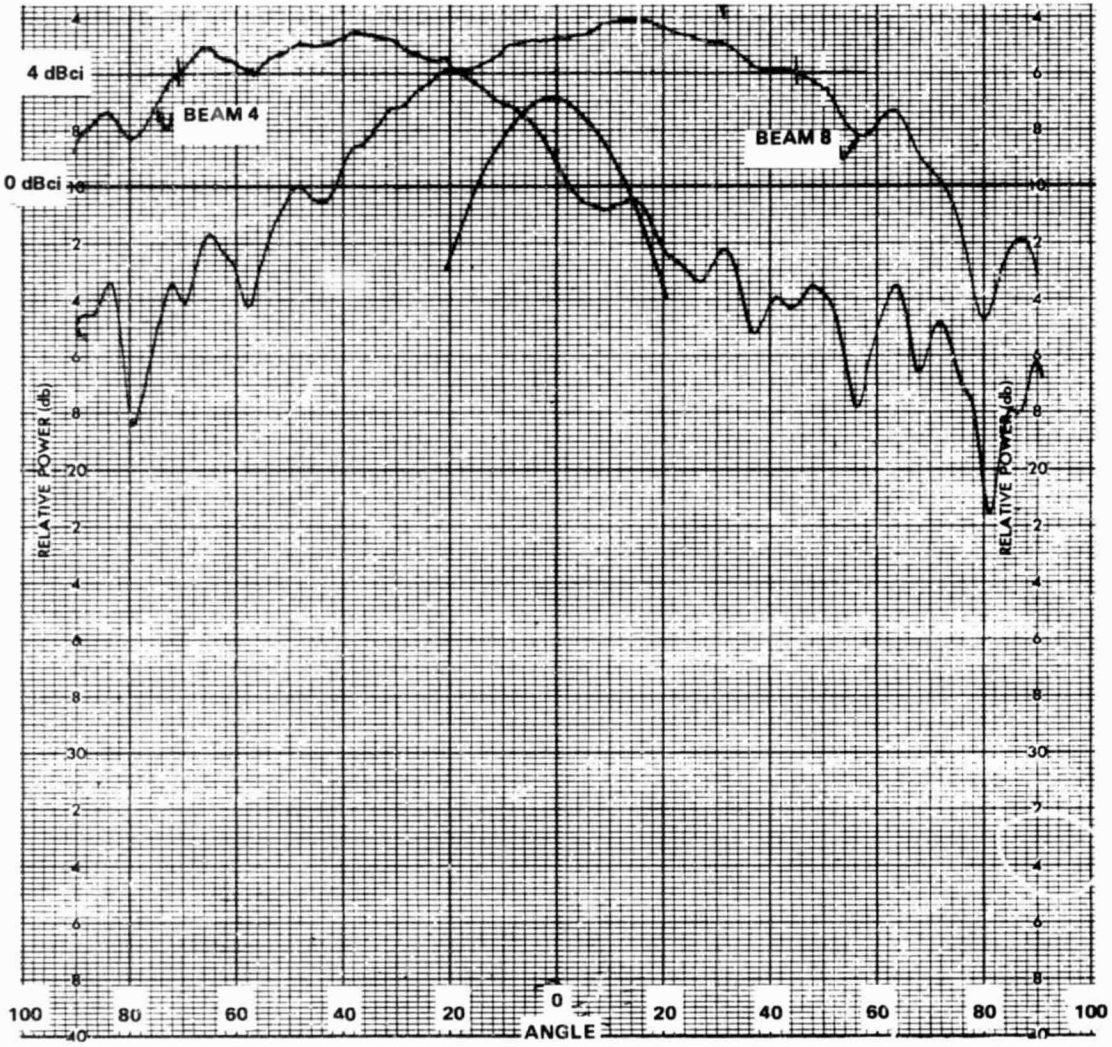
LOWER ANTENNA



2106.4 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 12.5° UP

MEASURED USING
SCAN ANGLES
FROM 2150 MHz

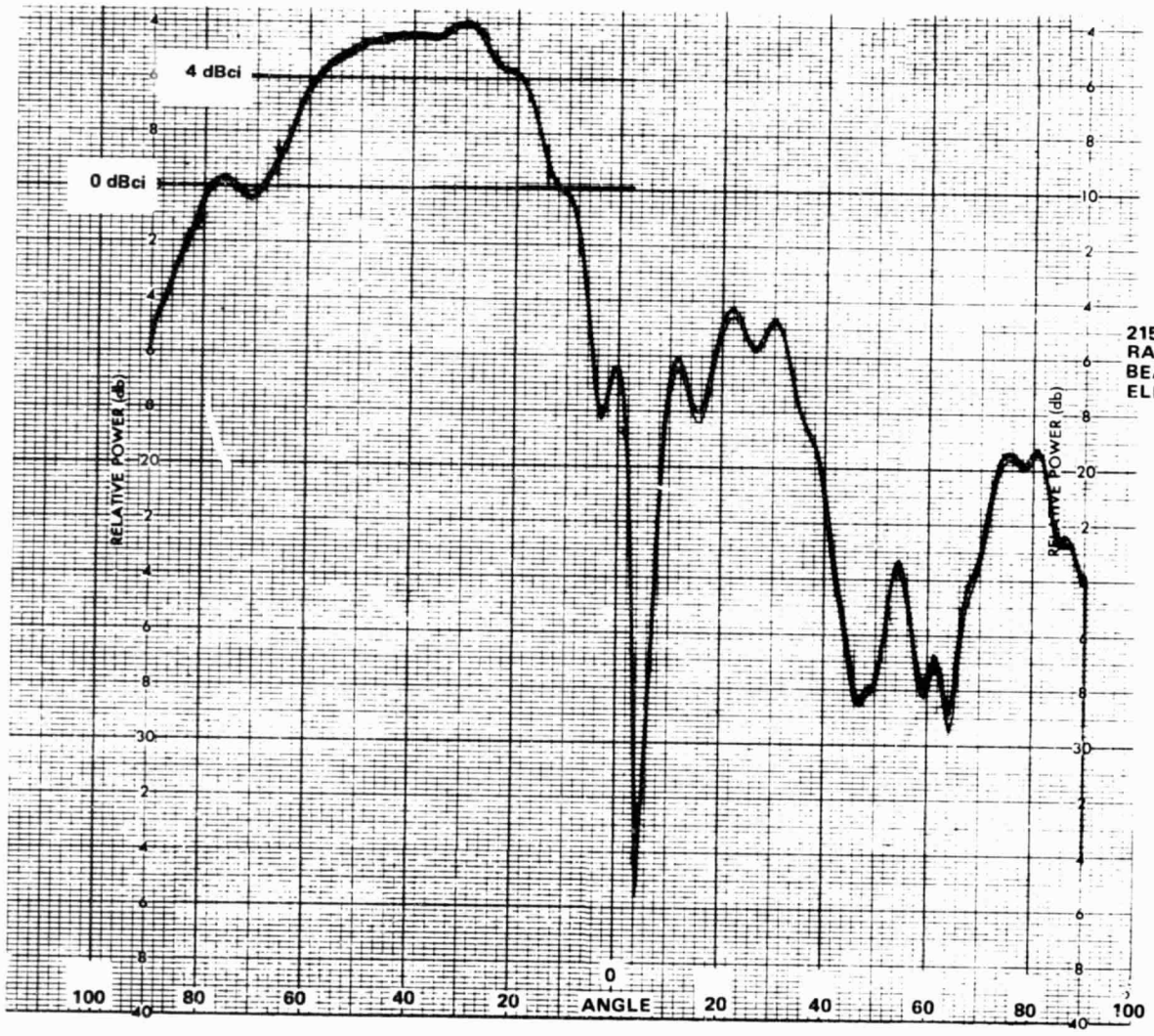
LOWER ANTENNA



2106.4 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 52.0° UP

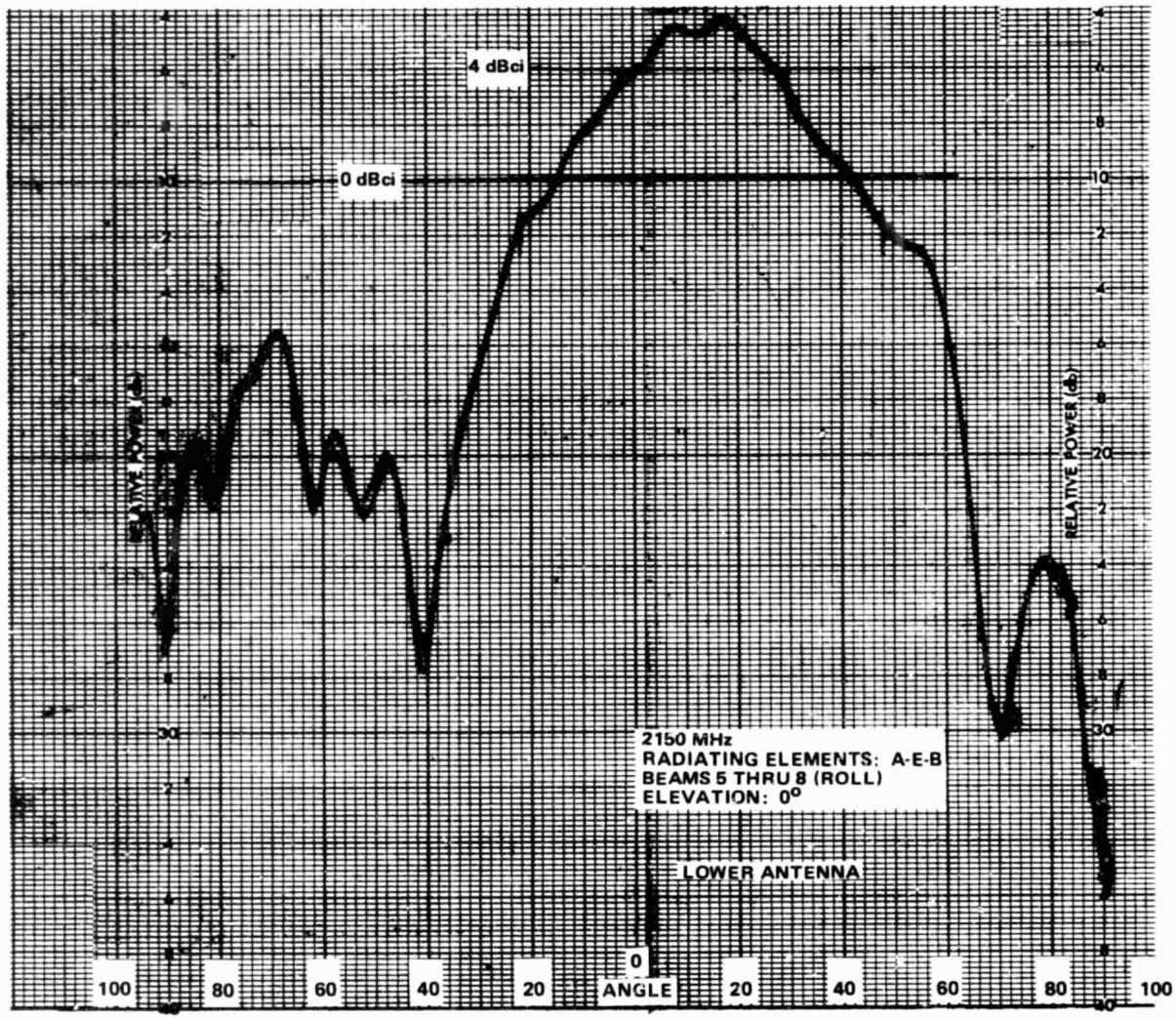
MEASURED USING
SCAN ANGLES
FROM 2150 MHz

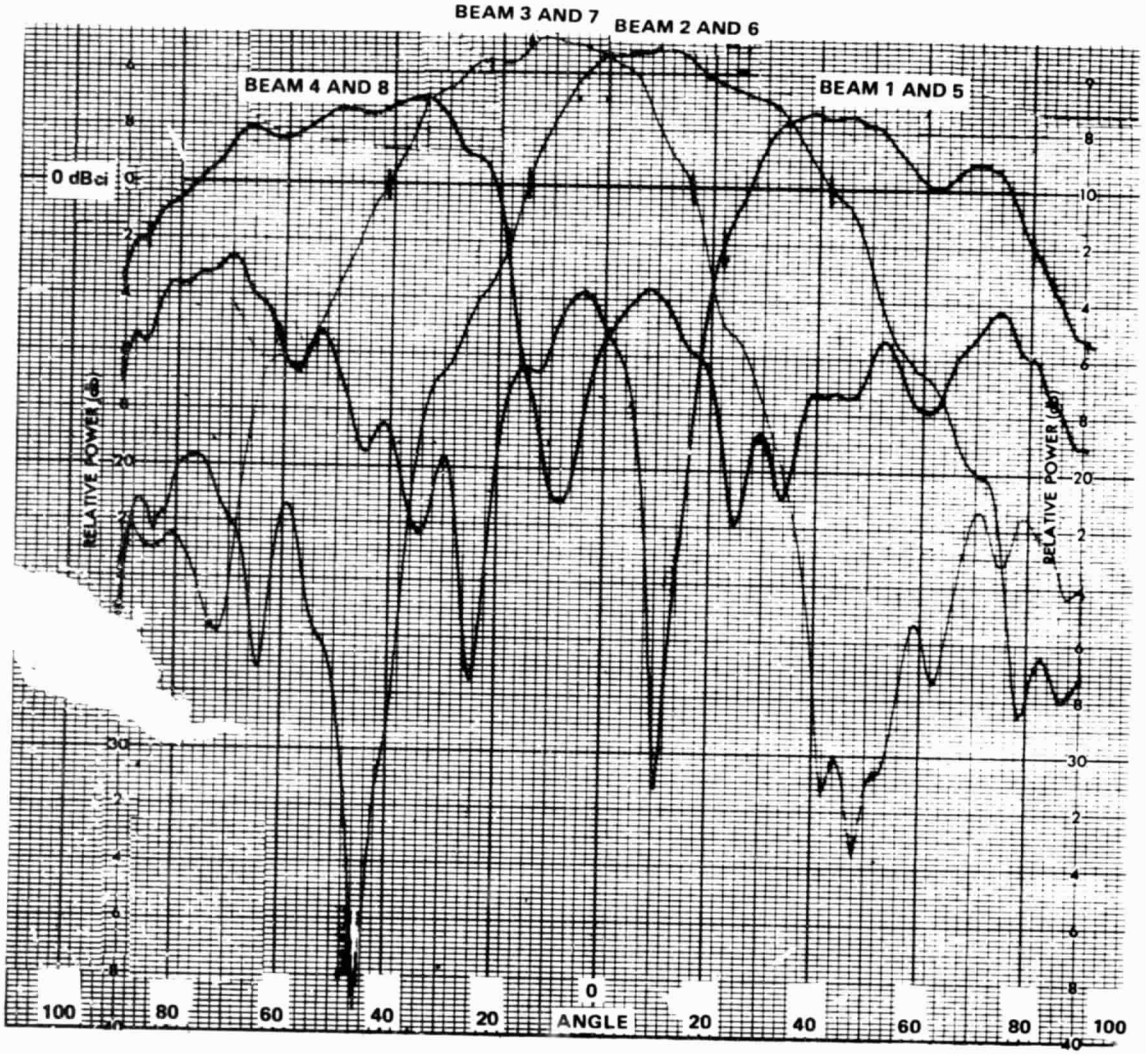
LOWER ANTENNA



2150 MHz
RADIATING ELEMENTS: A-E-B
BEAMS 1 THRU 4 (ROLL)
ELEVATION: 0°

LOWER ANTENNA


4 dBci
0 dBci
2150 MHz
RADIATING ELEMENTS: A-E-B
BEAMS 5 THRU 8 (ROLL)
ELEVATION: 0°
LOWER ANTENNA
RELATIVE POWER (dB)
RELATIVE POWER (dB)
100
80
60
40
20
0
ANGLE
20
40
60
80
100

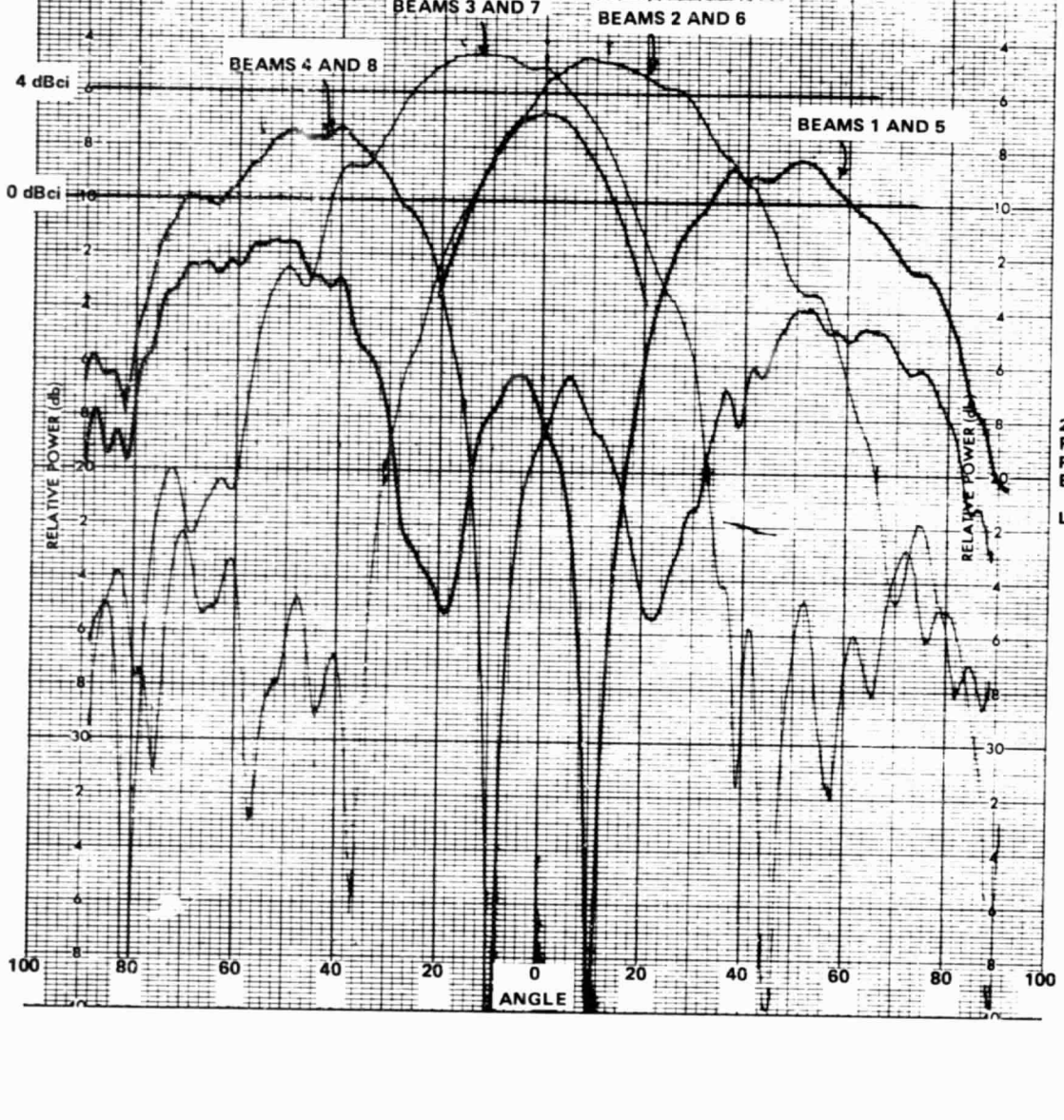


2150 MHz
RADIATING ELEMENTS: C-E-D
BEAMS 1 THRU 4, 5 THRU 8
ELEVATION: 0°

LOWER ANTENNA

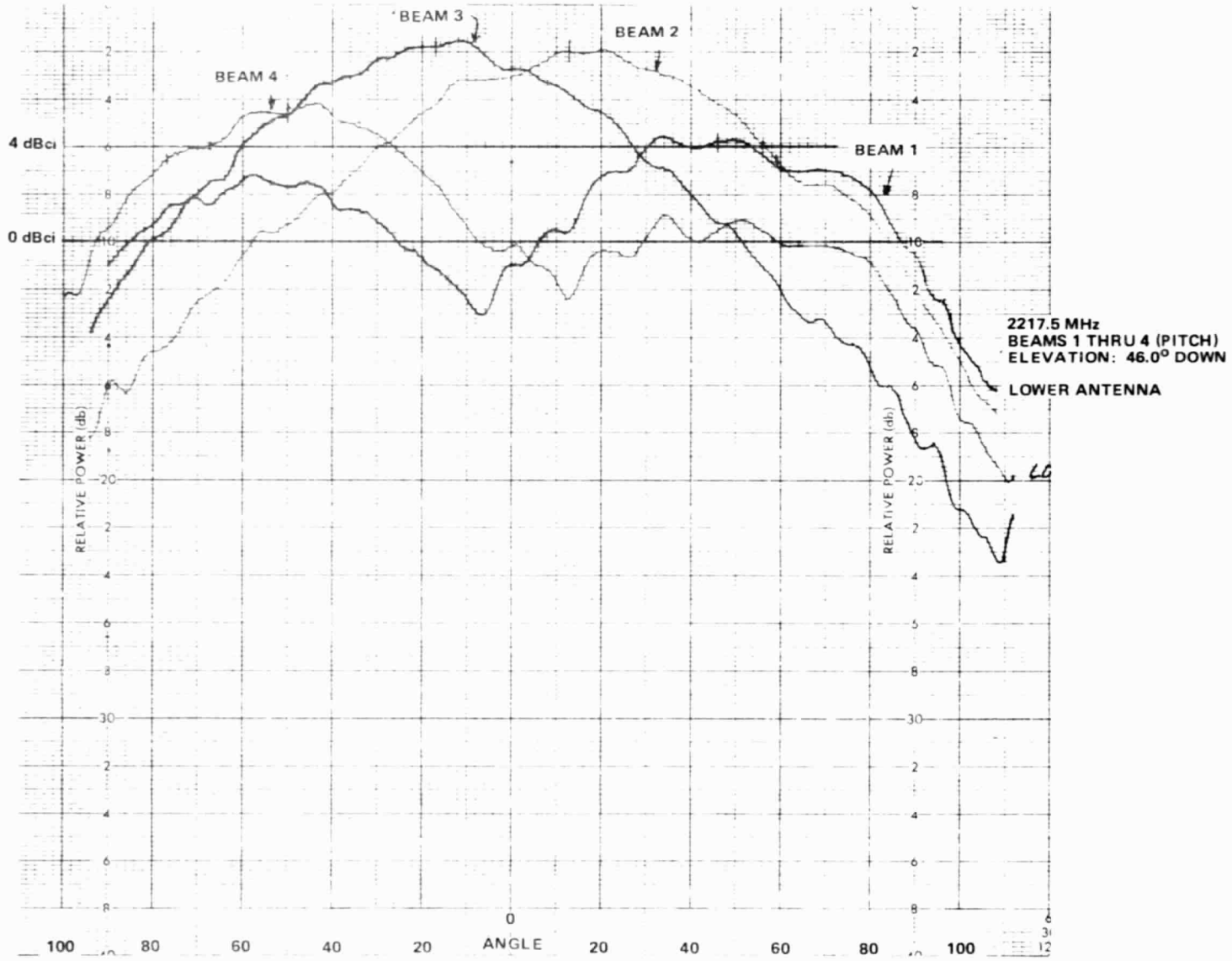
2217.5 MHz
RADIATING ELEMENTS:
A-E-B ROLL PLANE
ELEVATION: 0°

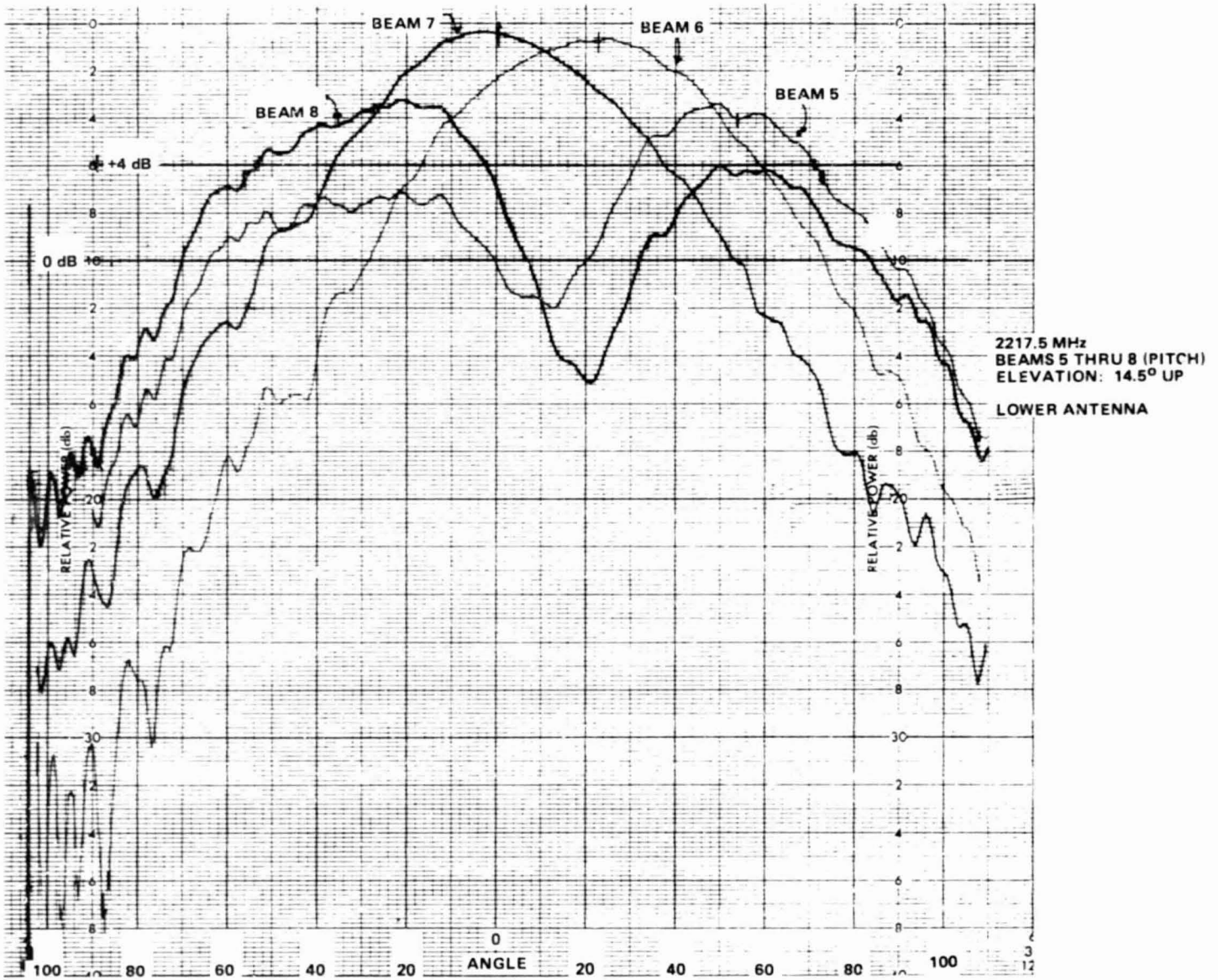
LOWER ANTENNA

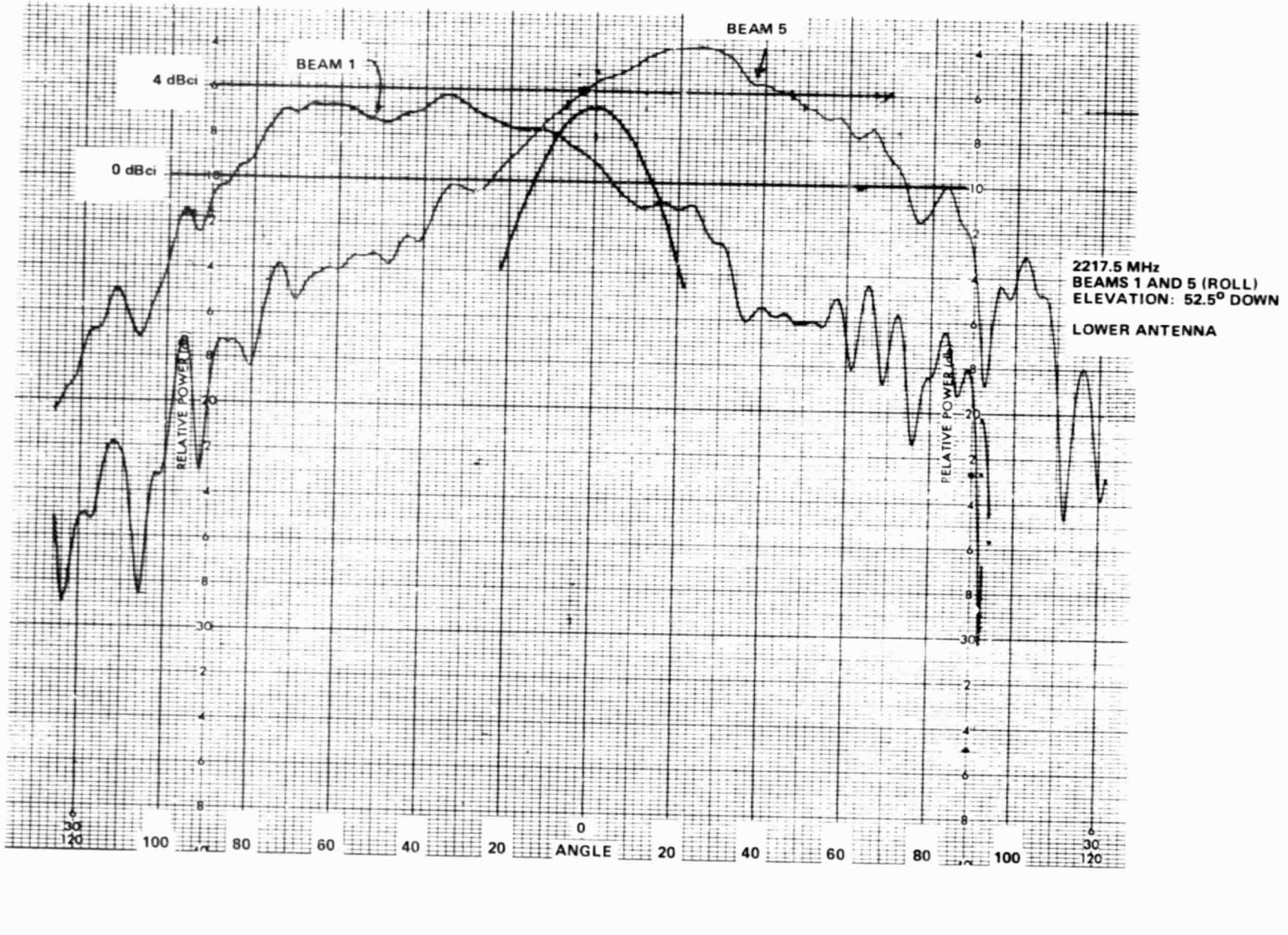


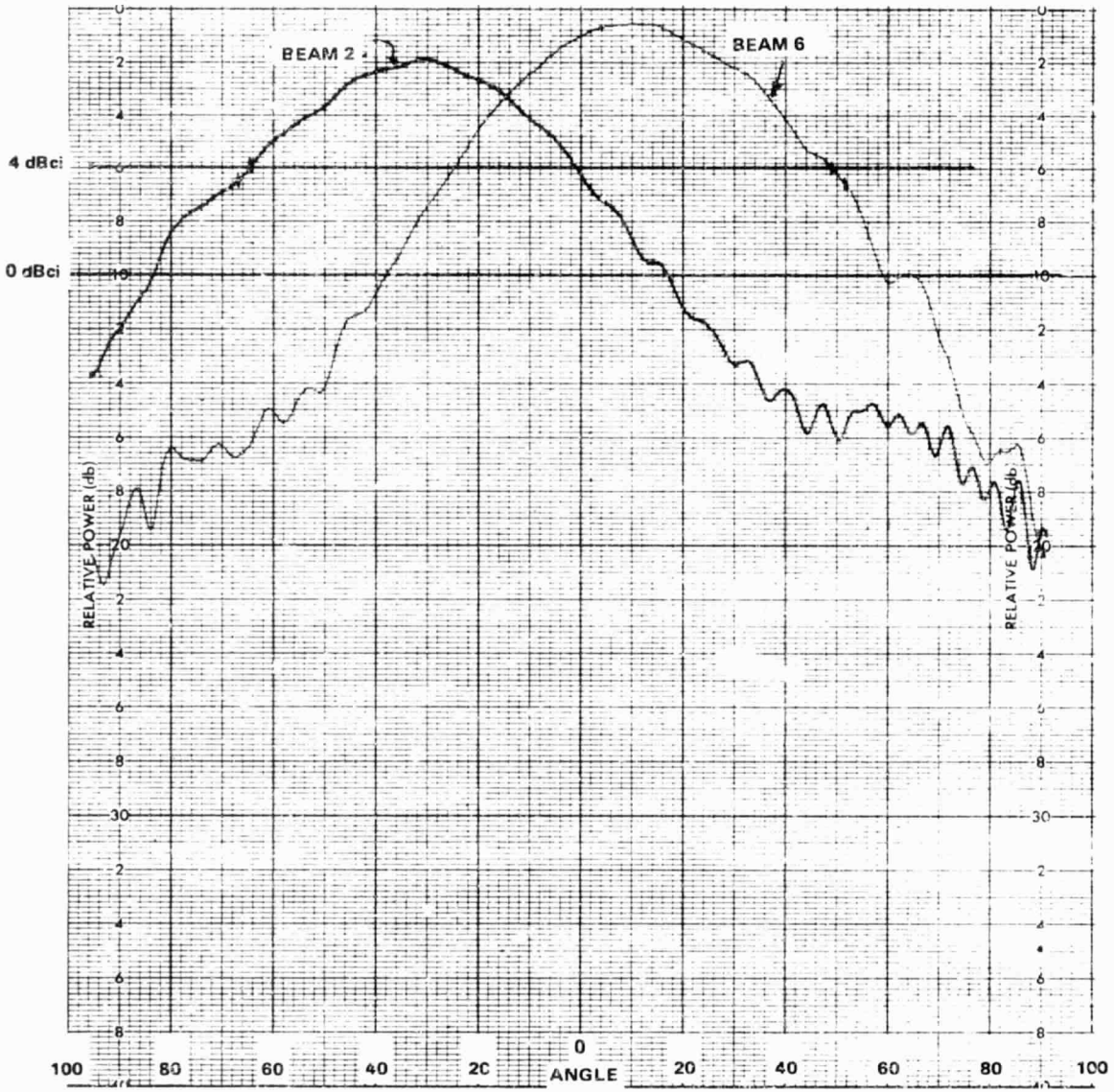
2217.5 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°

LOWER ANTENNA


BEAM 3
BEAM 2
BEAM 4
BEAM 1
4 dBci
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
100
80
60
40
20
0
20
40
60
80
100
2217.5 MHz
BEAMS 1 THRU 4 (PITCH)
ELEVATION: 46.0° DOWN
LOWER ANTENNA

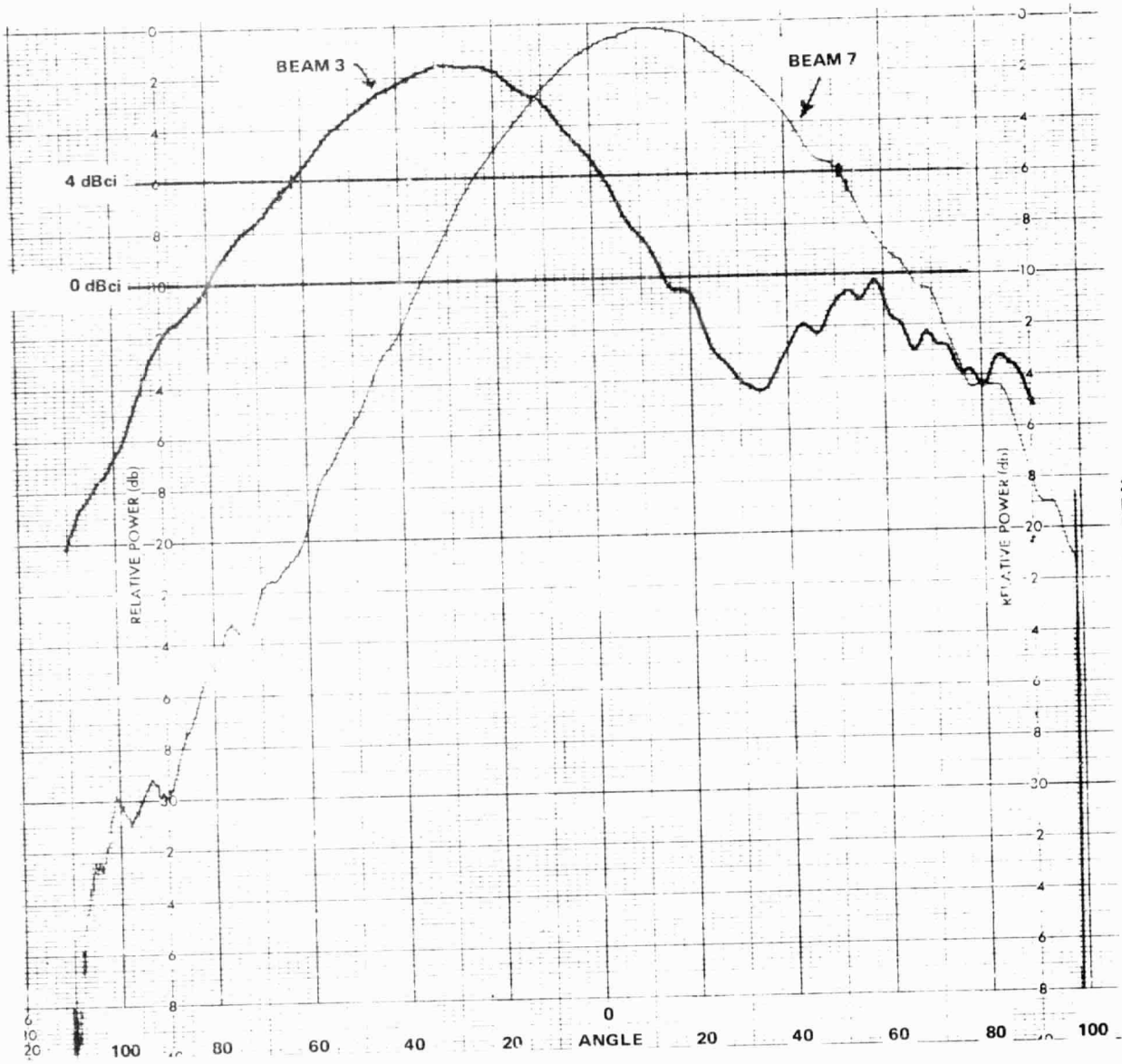

BEAM 7
BEAM 6
BEAM 5
BEAM 8
+4 dB
0 dB
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
100
80
60
40
20
0
20
40
60
80
100
2217.5 MHz
BEAMS 5 THRU 8 (PITCH)
ELEVATION: 14.5° UP
LOWER ANTENNA


BEAM 5
BEAM 1
4 dBci
0 dBci
RELATIVE POWER (dB)
RELATIVE POWER (dB)
ANGLE
2217.5 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 52.5° DOWN
LOWER ANTENNA



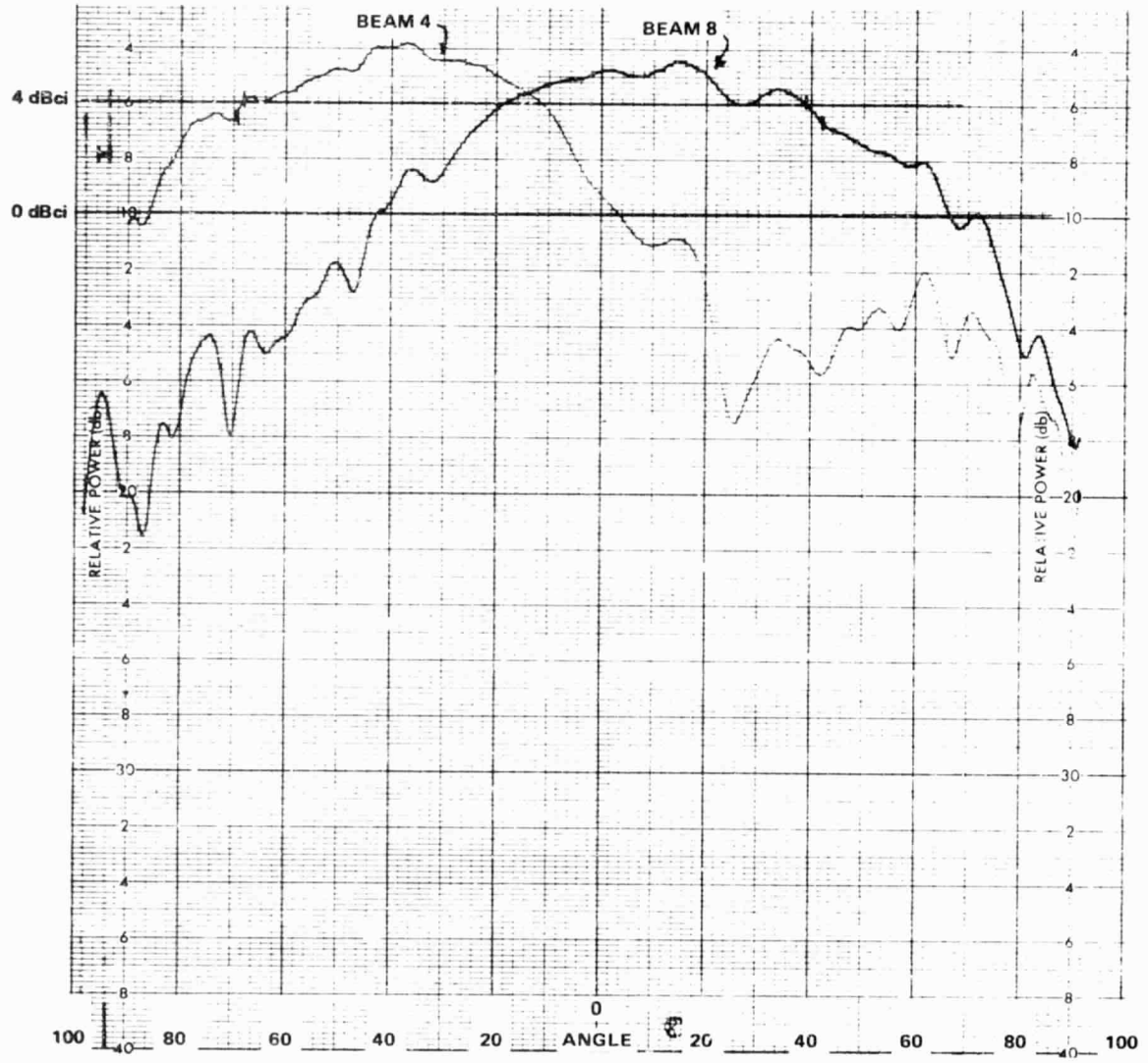
2217.5 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 17.5° DOWN

LOWER ANTENNA



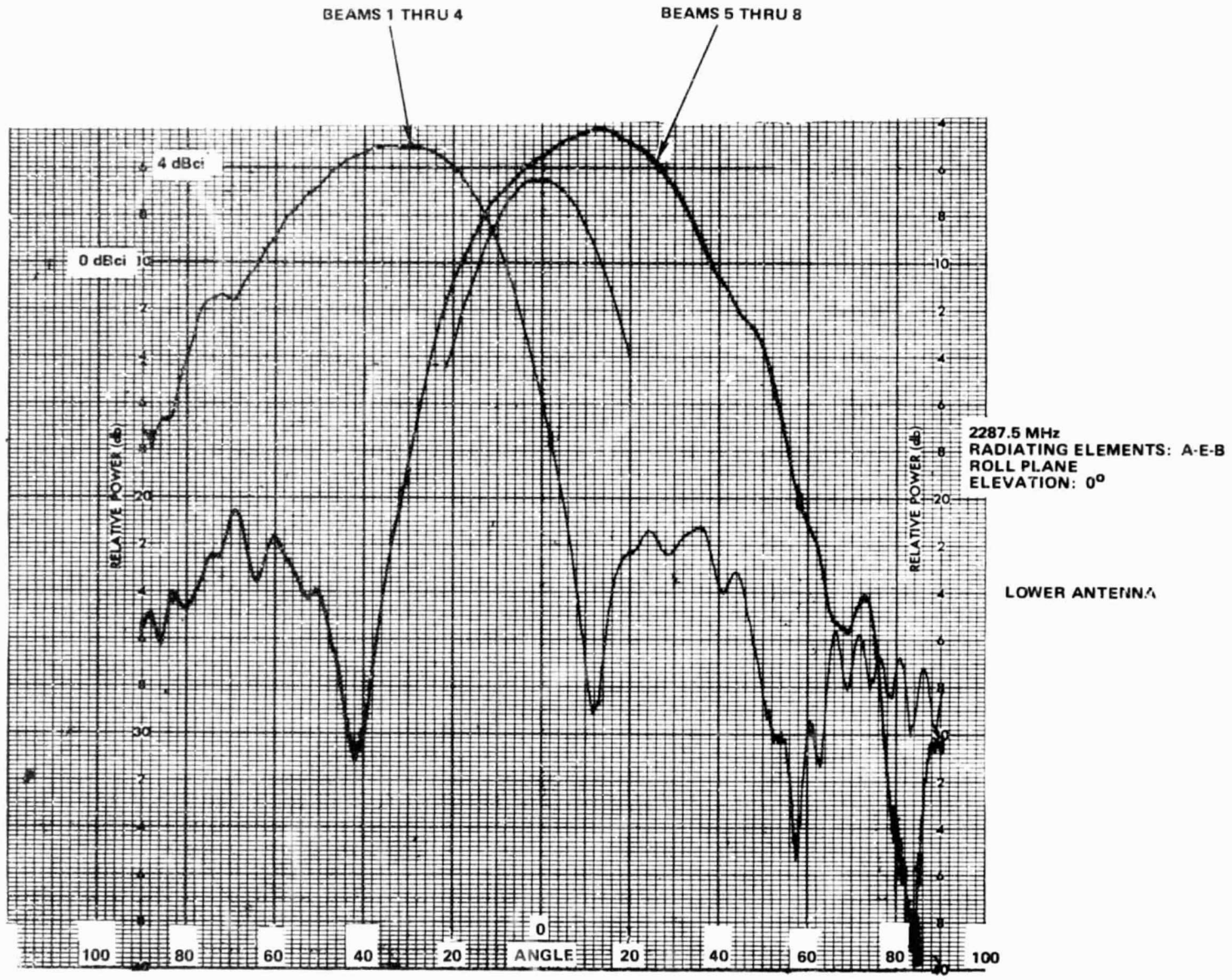
2217.5 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 13.5° UP

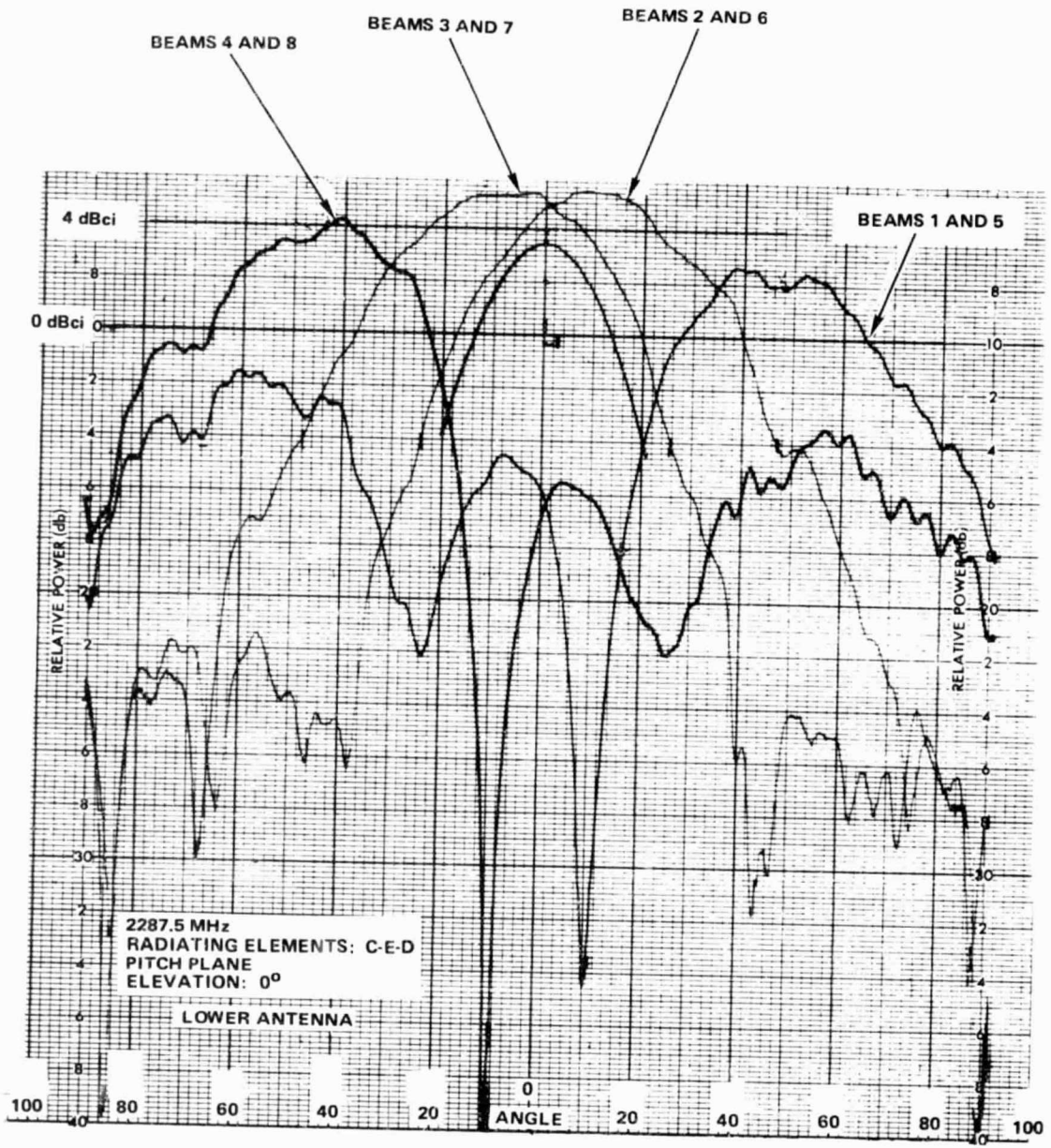
LOWER ANTENNA

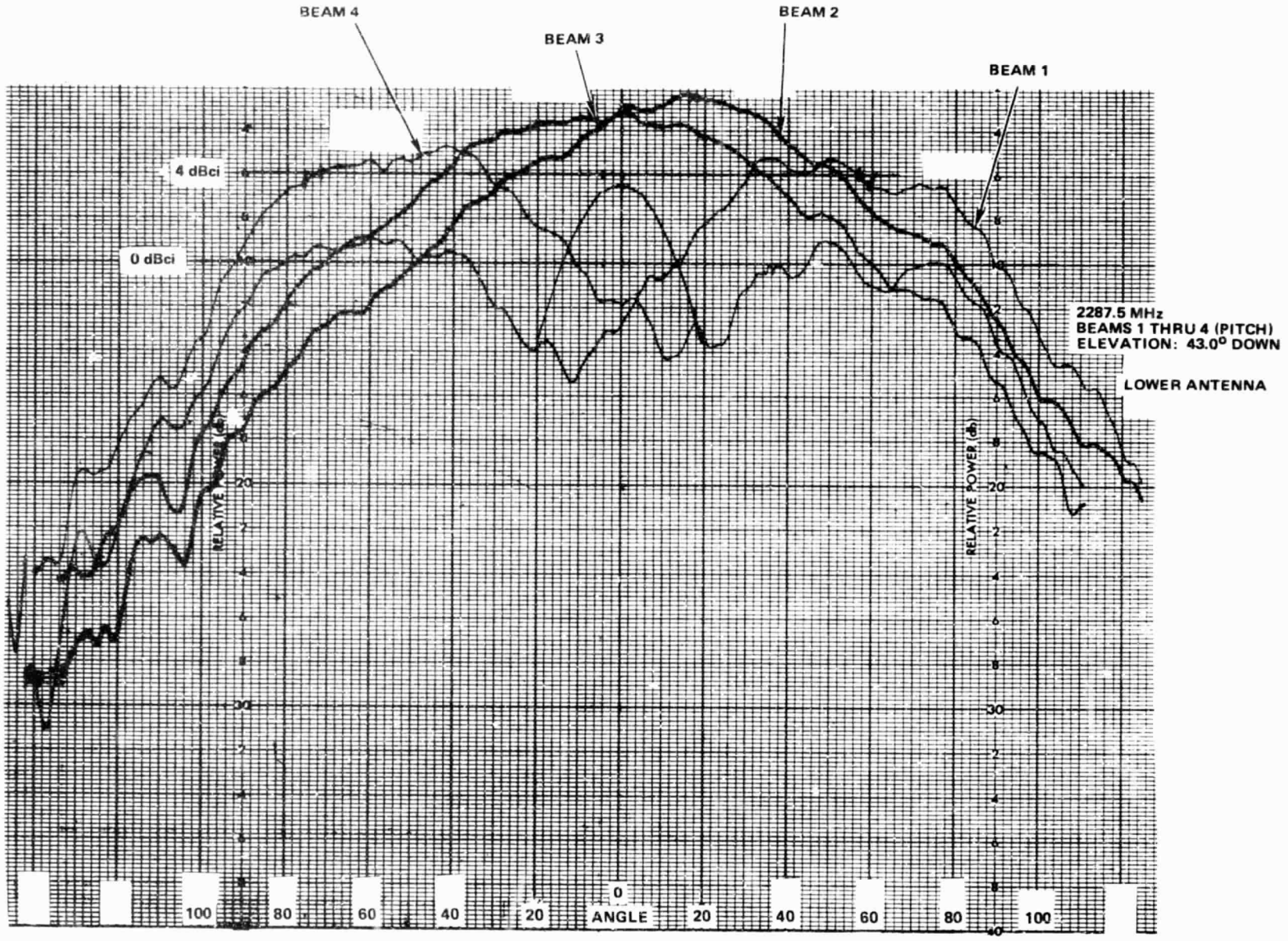


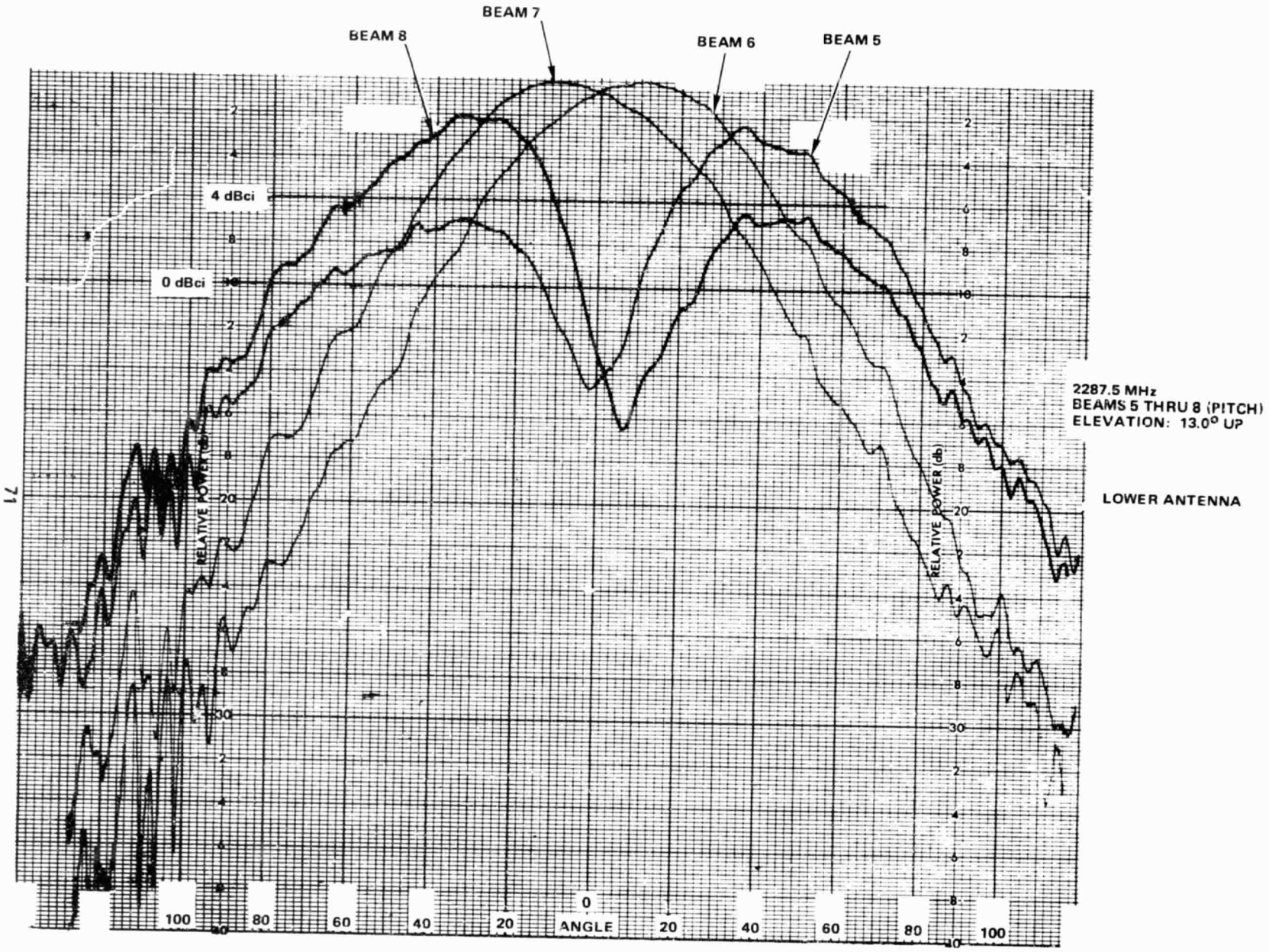
2217.5 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 48.5° UP

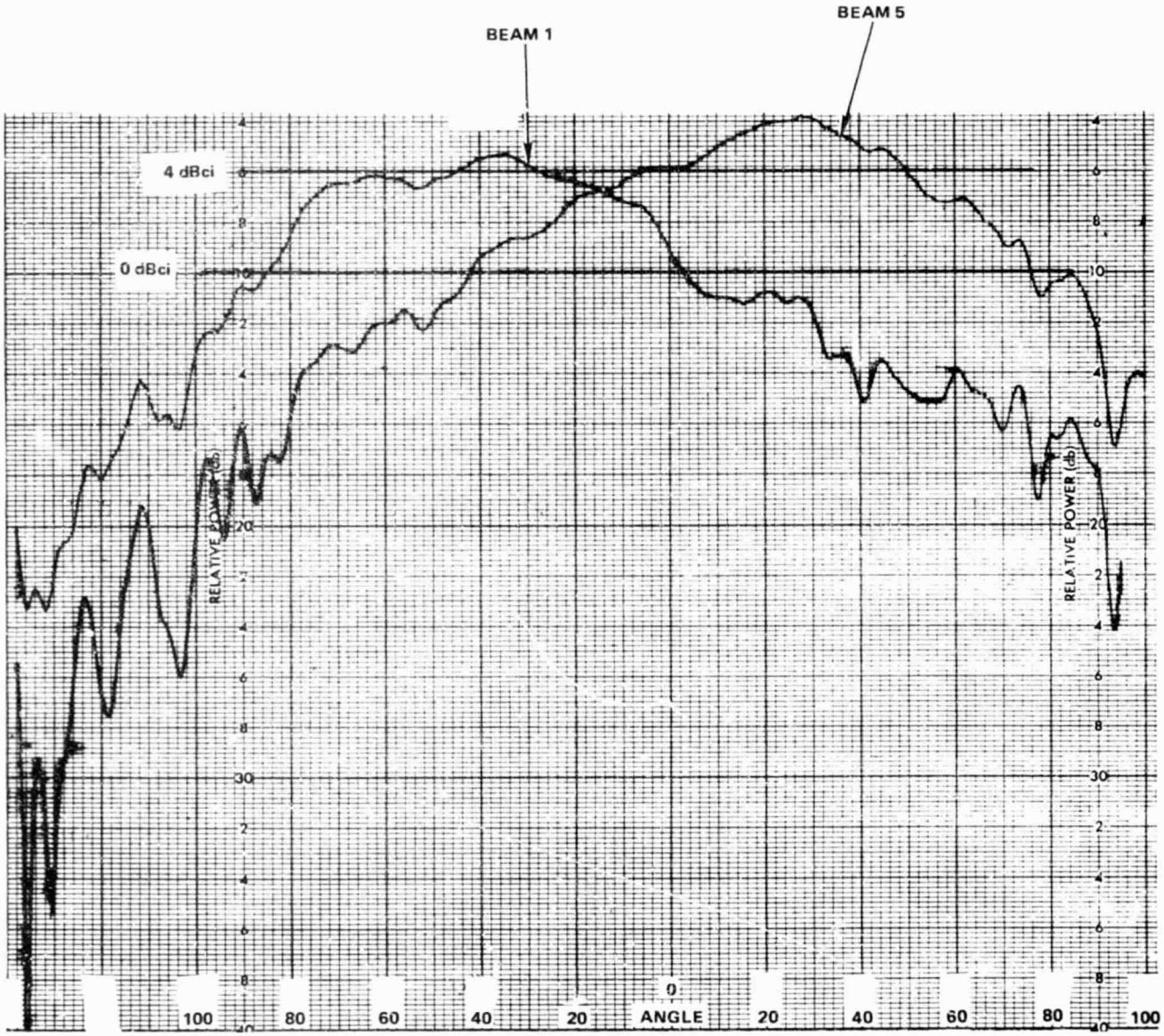
LOWER ANTENNA


BEAMS 1 THRU 4
BEAMS 5 THRU 8
4 dBci
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
100
80
60
40
20
0
ANGLE
20
40
60
80
100
2287.5 MHz
RADIATING ELEMENTS: A-E-B
ROLL PLANE
ELEVATION: 0°
LOWER ANTENNA


BEAMS 4 AND 8
BEAMS 3 AND 7
BEAMS 2 AND 6
BEAMS 1 AND 5
4 dBci
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
2287.5 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°
LOWER ANTENNA
100
80
60
40
20
0
ANGLE
20
40
60
80
100

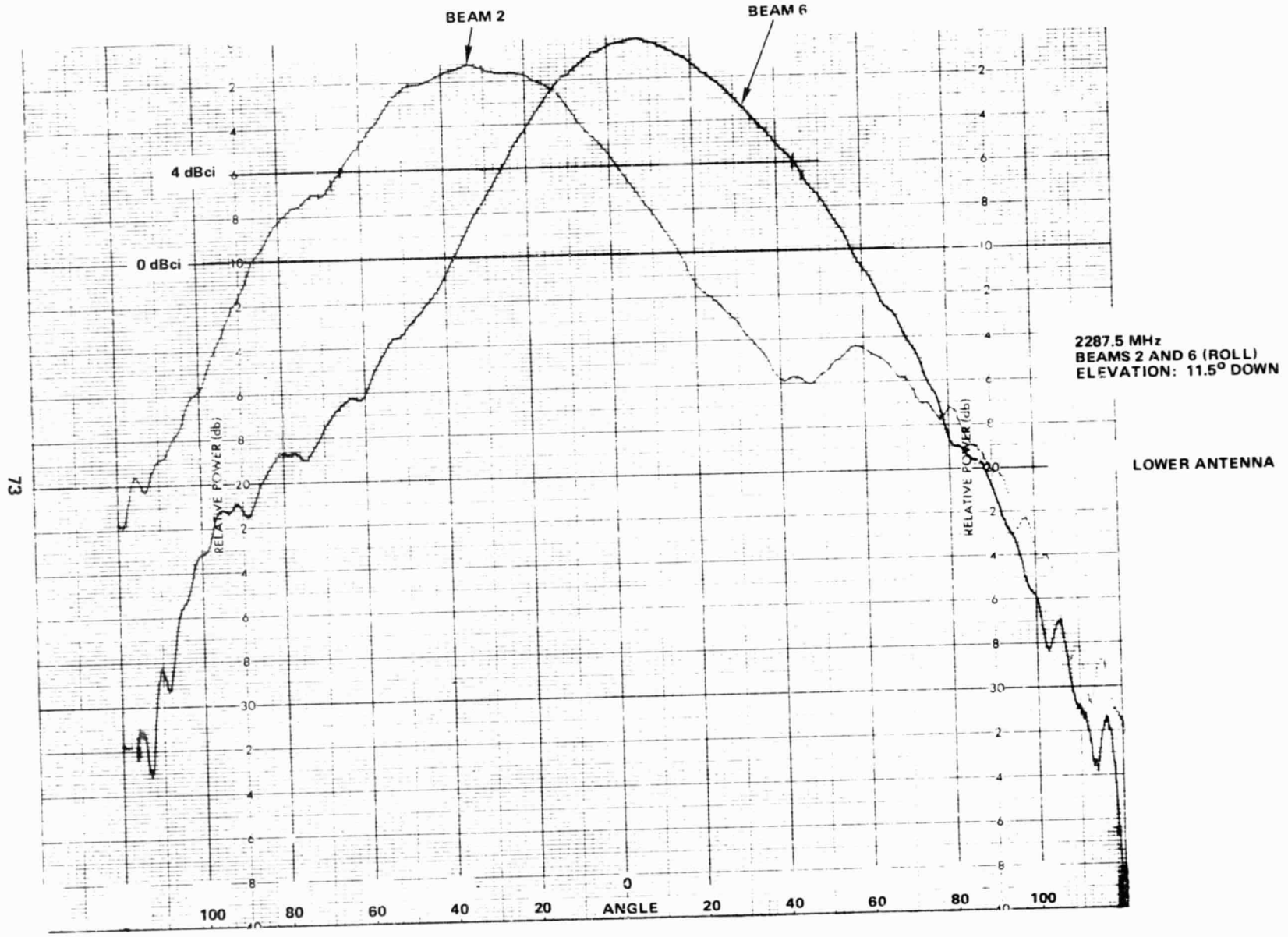

BEAM 4
BEAM 3
BEAM 2
BEAM 1
4 dBci
0 dBci
2287.5 MHz
BEAMS 1 THRU 4 (PITCH)
ELEVATION: 43.0° DOWN
LOWER ANTENNA
RELATIVE POWER (dB)
RELATIVE POWER (dB)
100
80
60
40
20
0
ANGLE
20
40
60
80
100

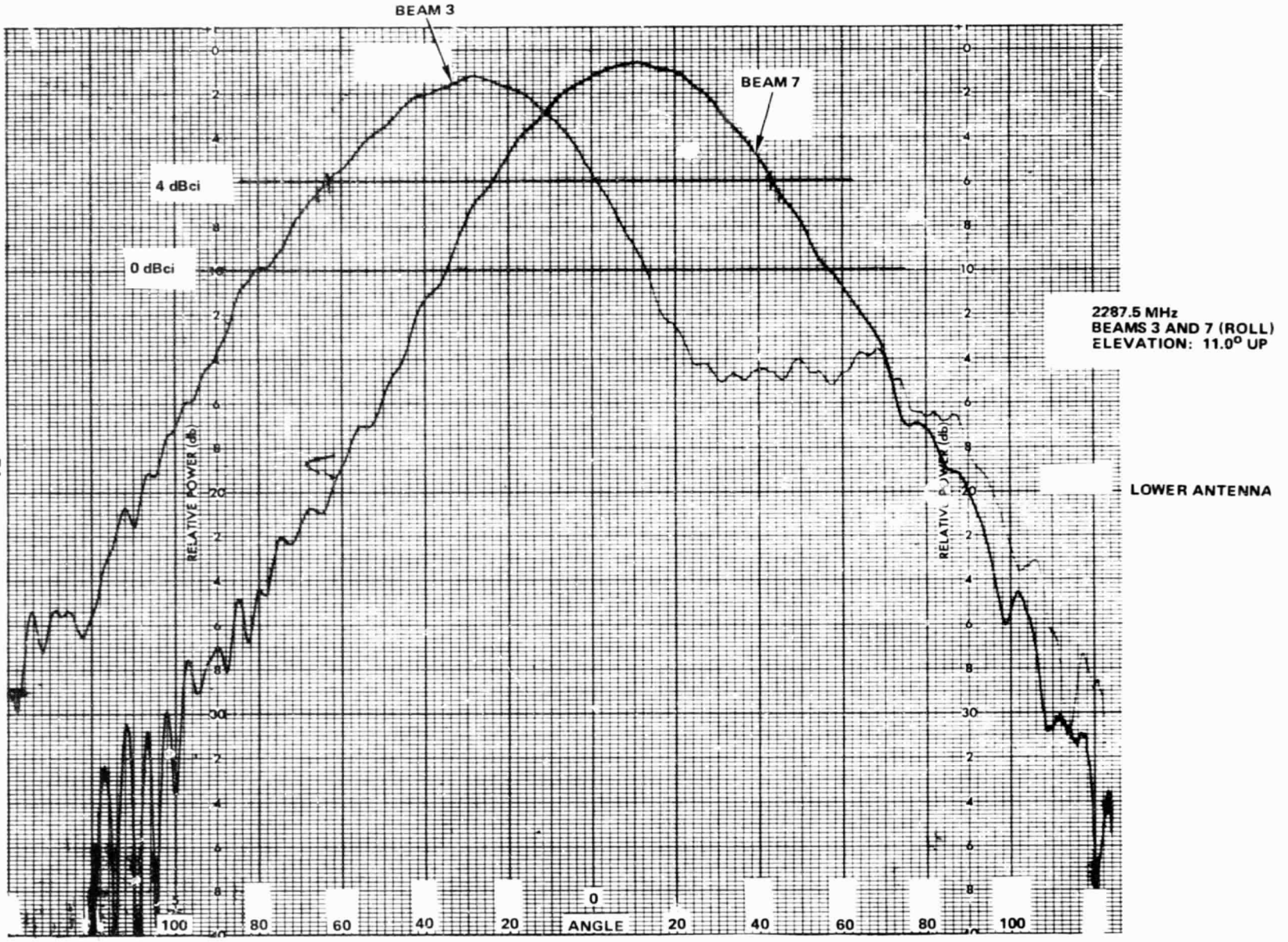

BEAM 8
BEAM 7
BEAM 6
BEAM 5
4 dBci
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
100
80
60
40
20
0
ANGLE
20
40
60
80
100
2287.5 MHz
BEAMS 5 THRU 8 (PITCH)
ELEVATION: 13.0° UP
LOWER ANTENNA

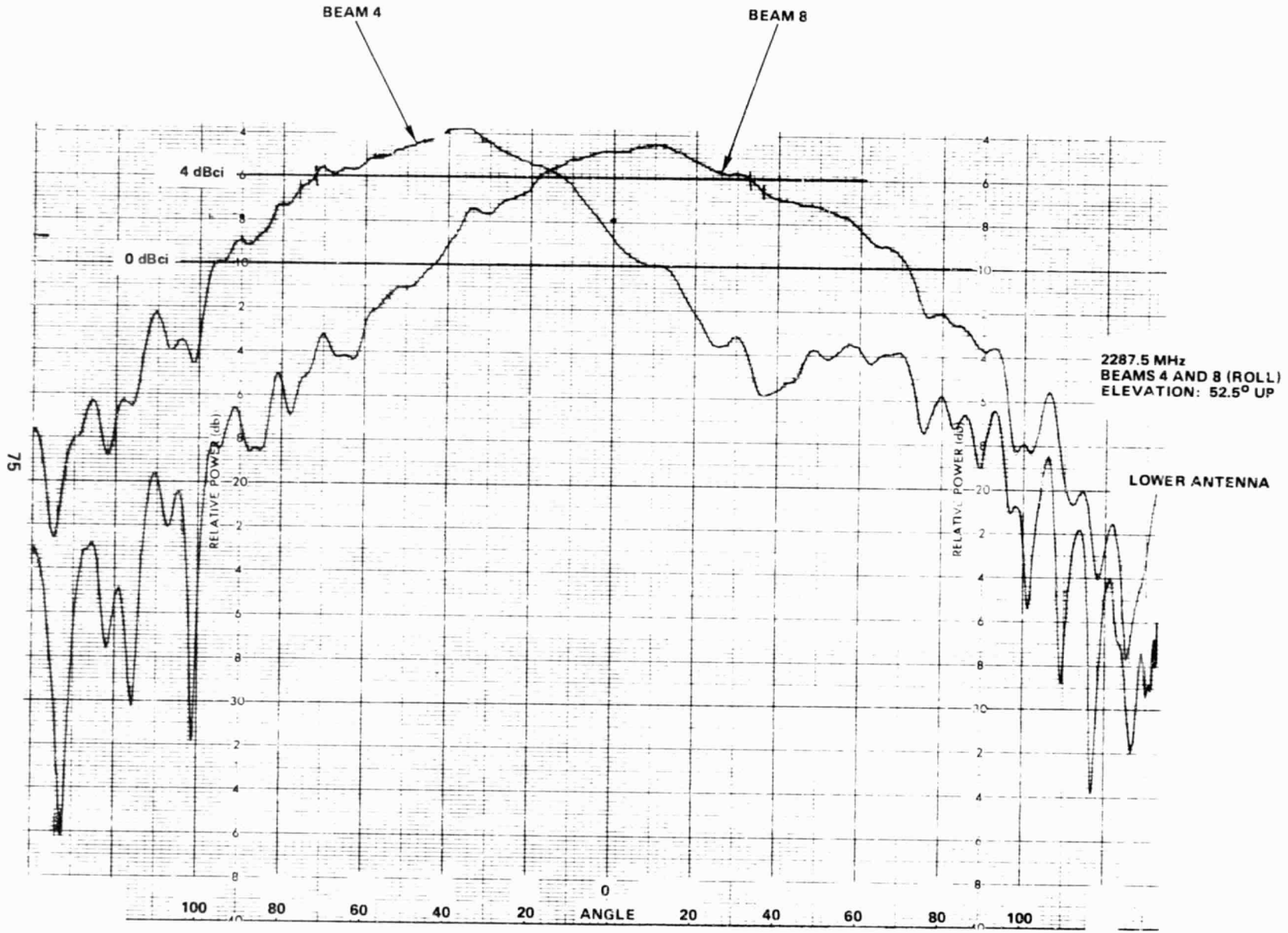


2287.5 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 53.5° DOWN

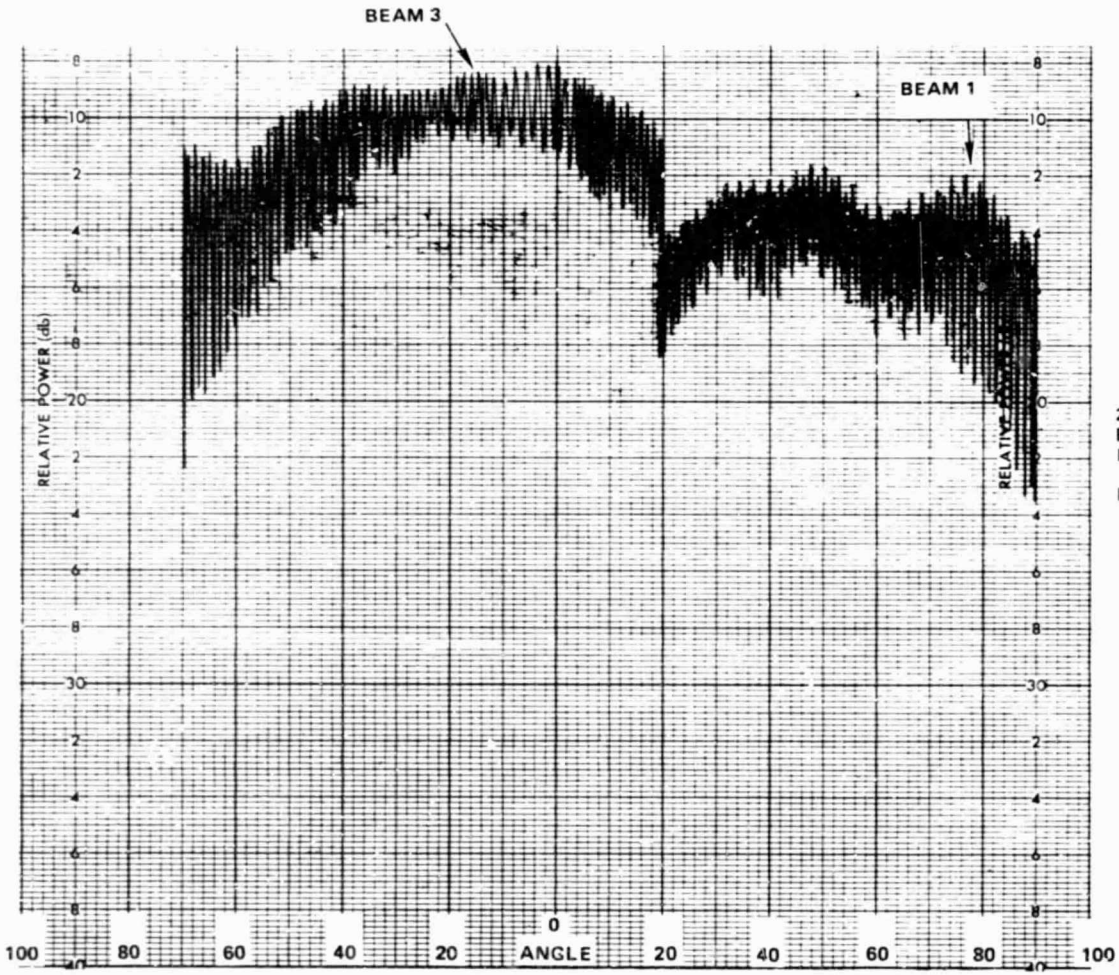
LOWER ANTENNA


BEAM 2
BEAM 6
4 dBci
0 dBci
RELATIVE POWER (db)
RELATIVE POWER (db)
100
80
60
40
20
0
ANGLE
20
40
60
80
100
2287.5 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 11.5° DOWN
LOWER ANTENNA


BEAM 3
BEAM 7
4 dBci
0 dBci
RELATIVE POWER (db)
ANGLE
100
80
60
40
20
0
20
40
60
80
100
2287.5 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 11.0° UP
LOWER ANTENNA

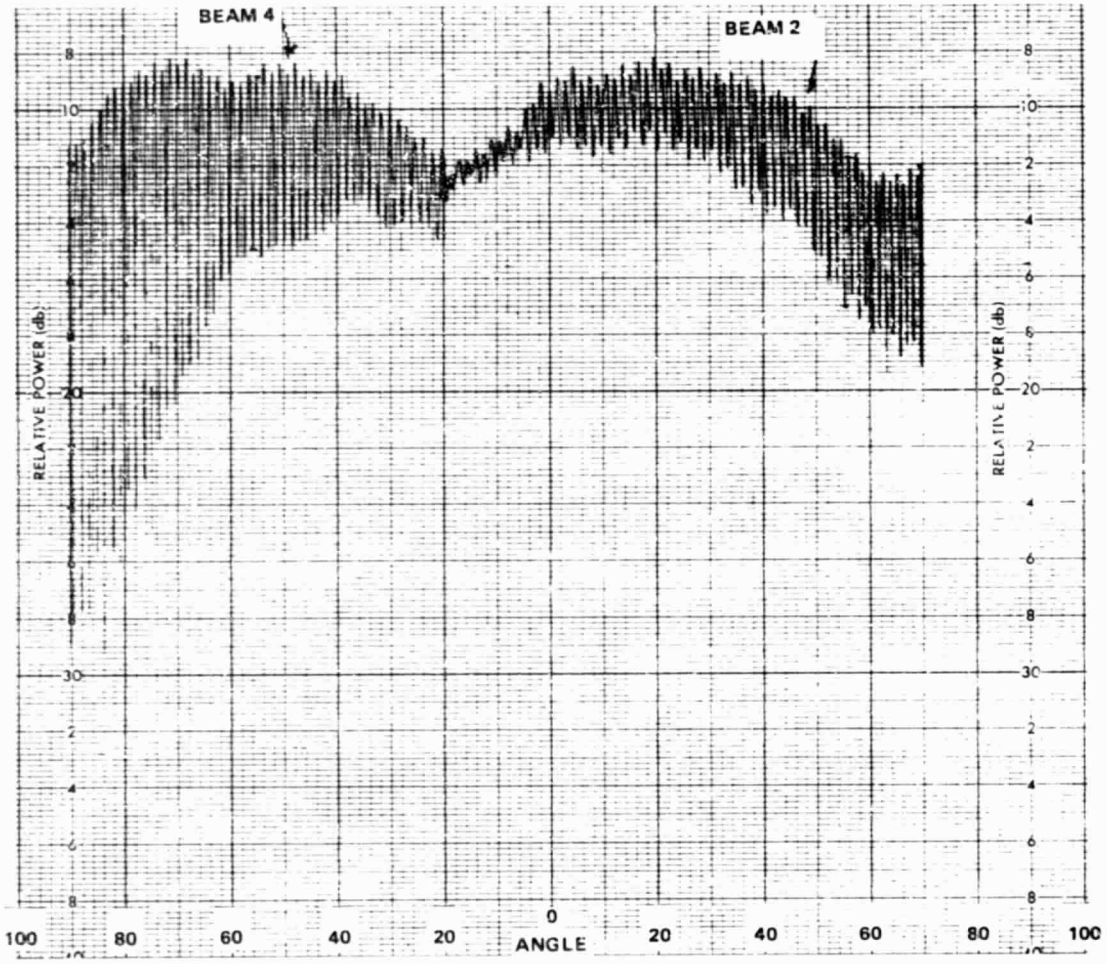

BEAM 4
BEAM 8
4 dBci
0 dBci
2287.5 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 52.5° UP
LOWER ANTENNA
RELATIVE POWER (db)
RELATIVE POWER (db)
100
80
60
40
20
0
ANGLE
20
40
60
80
100

9. AXIAL RATIO PATTERNS



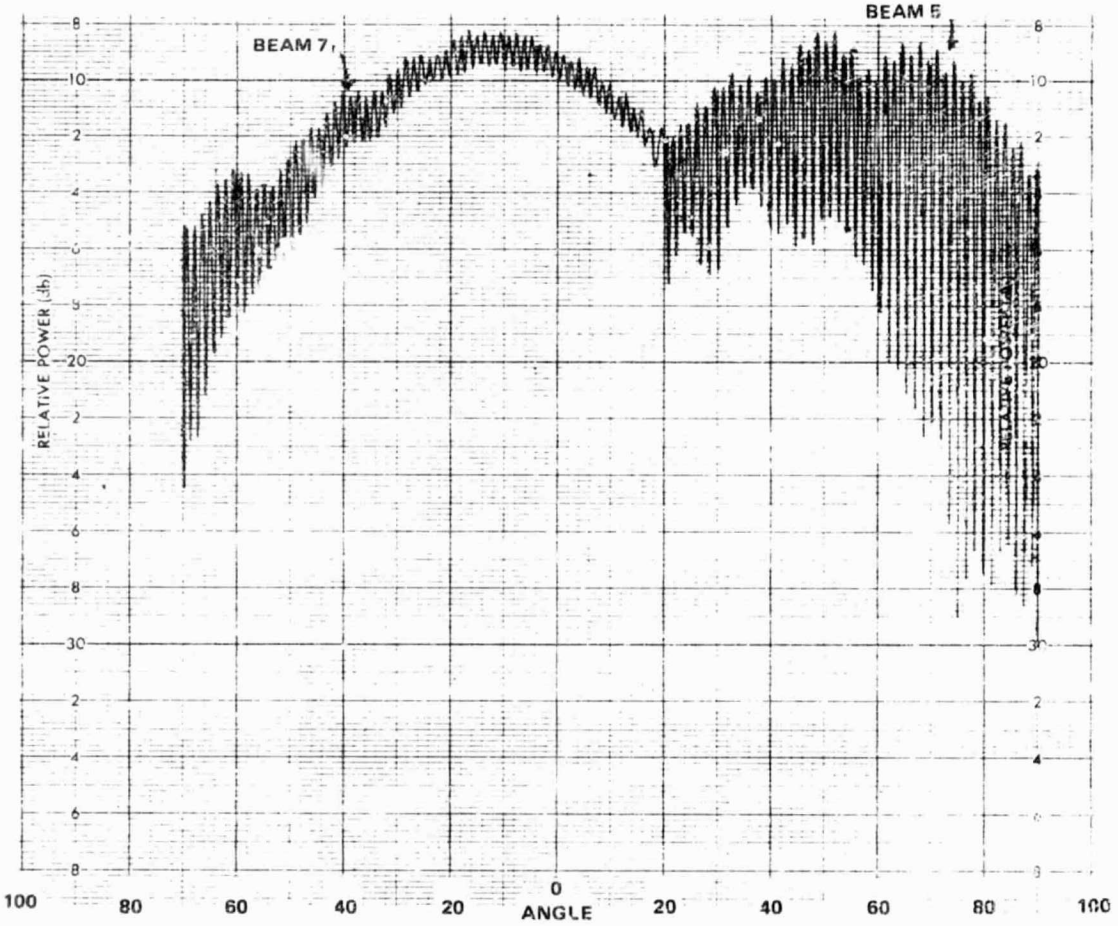
2041.9 MHz
BEAMS 1 AND 3 (PITCH)
ELEVATION: 38.5° DOWN

LOWER ANTENNA



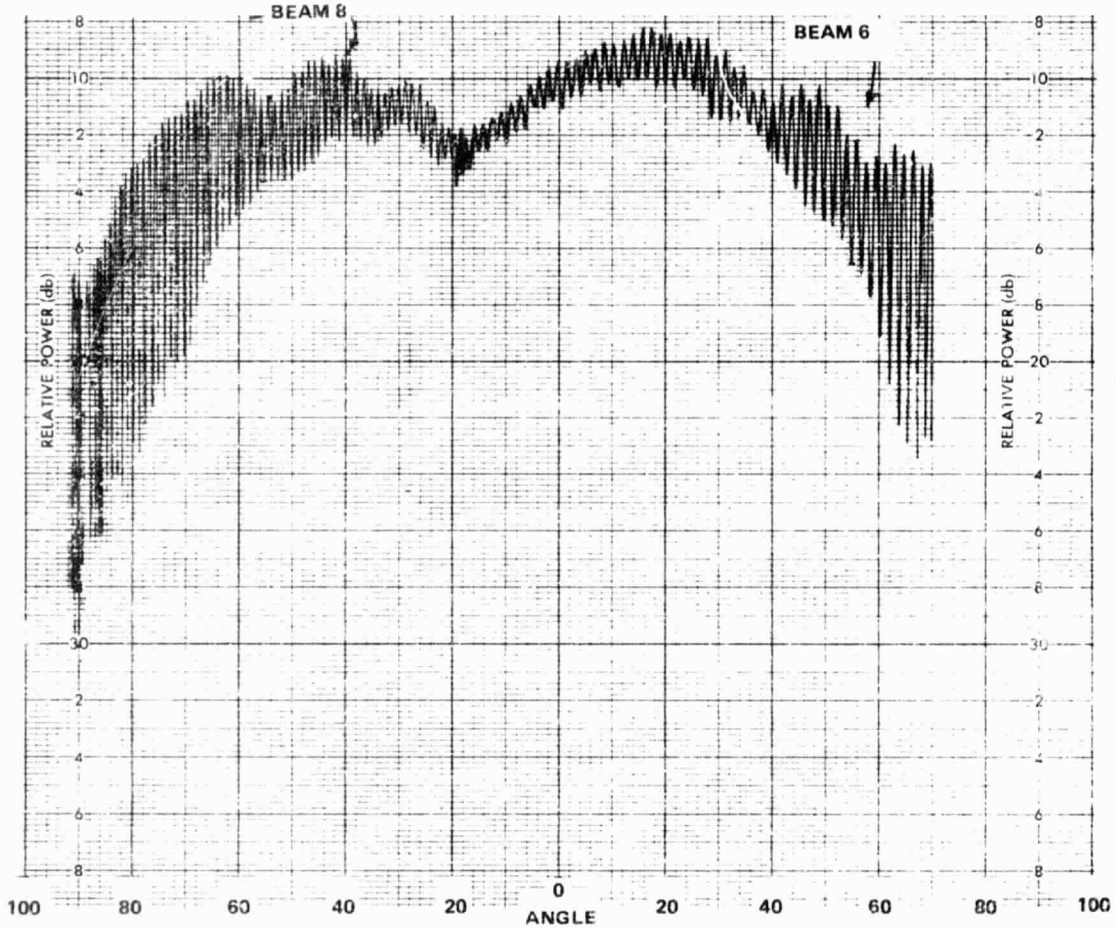
2041.9 MHz
BEAMS 2 AND 4 (PITCH)
ELEVATION: 38.5° DOWN

LOWER ANTENNA



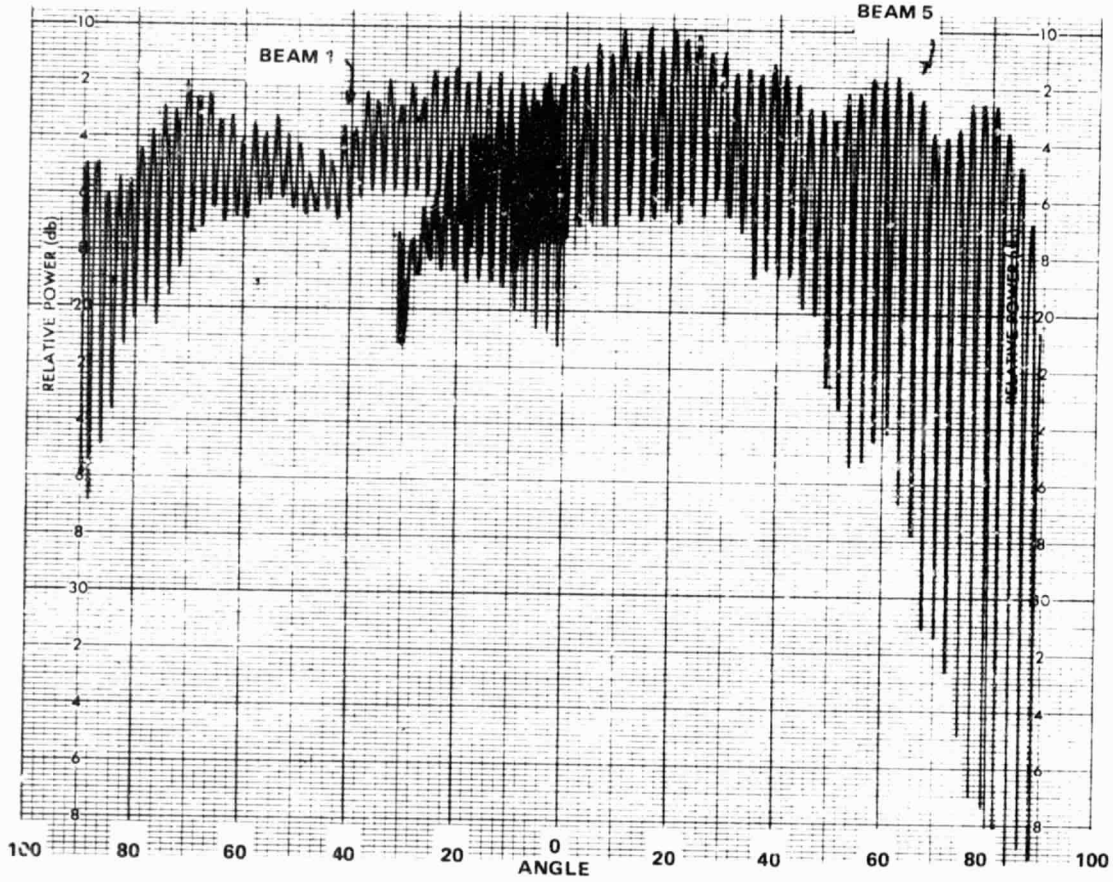
2041.9 MHz
BEAMS 5 AND 7 (PITCH)
ELEVATION: 19.5° UP

LOWER ANTENNA



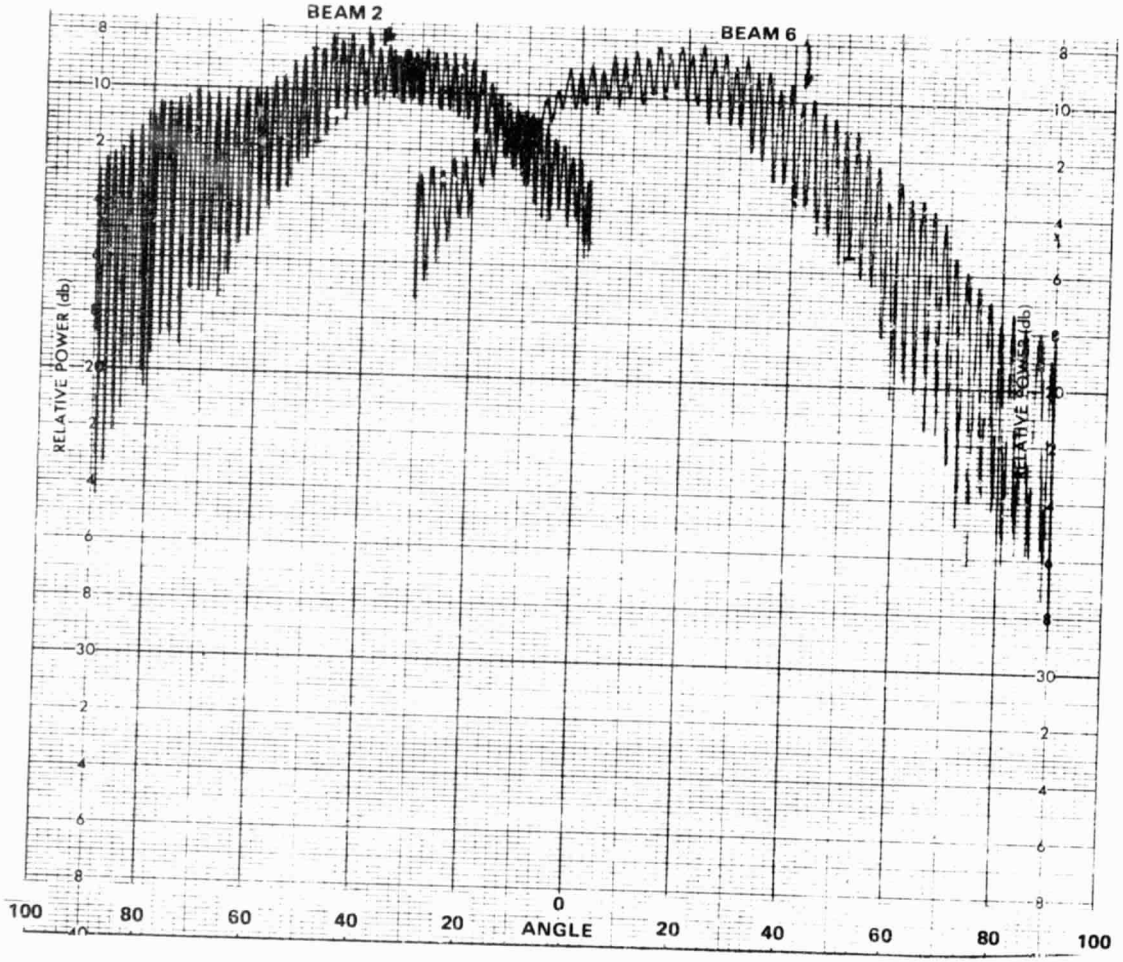
2041.9 MHz
BEAMS 6 AND 8 (PITCH)
ELEVATION: 19.5° UP

LOWER ANTENNA



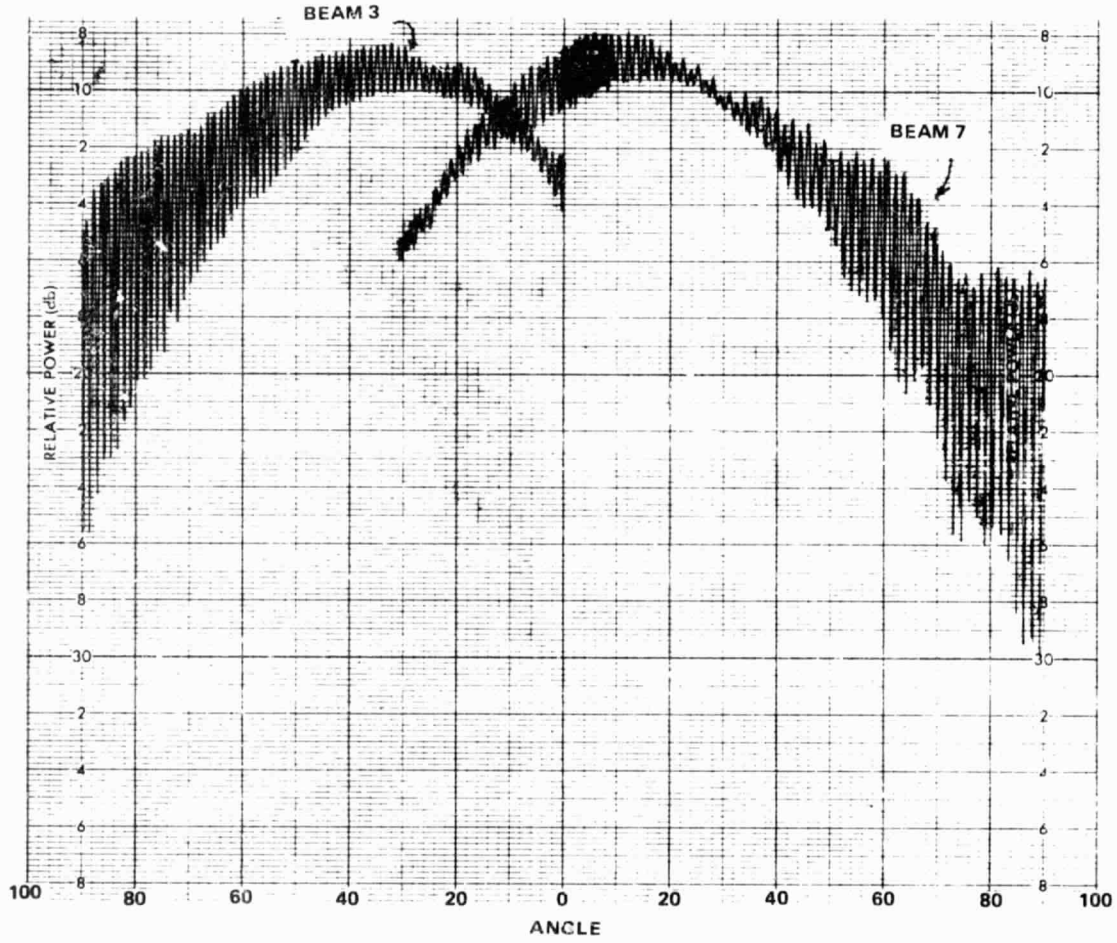
2041.9 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 53.0° DOWN

LOWER ANTENNA



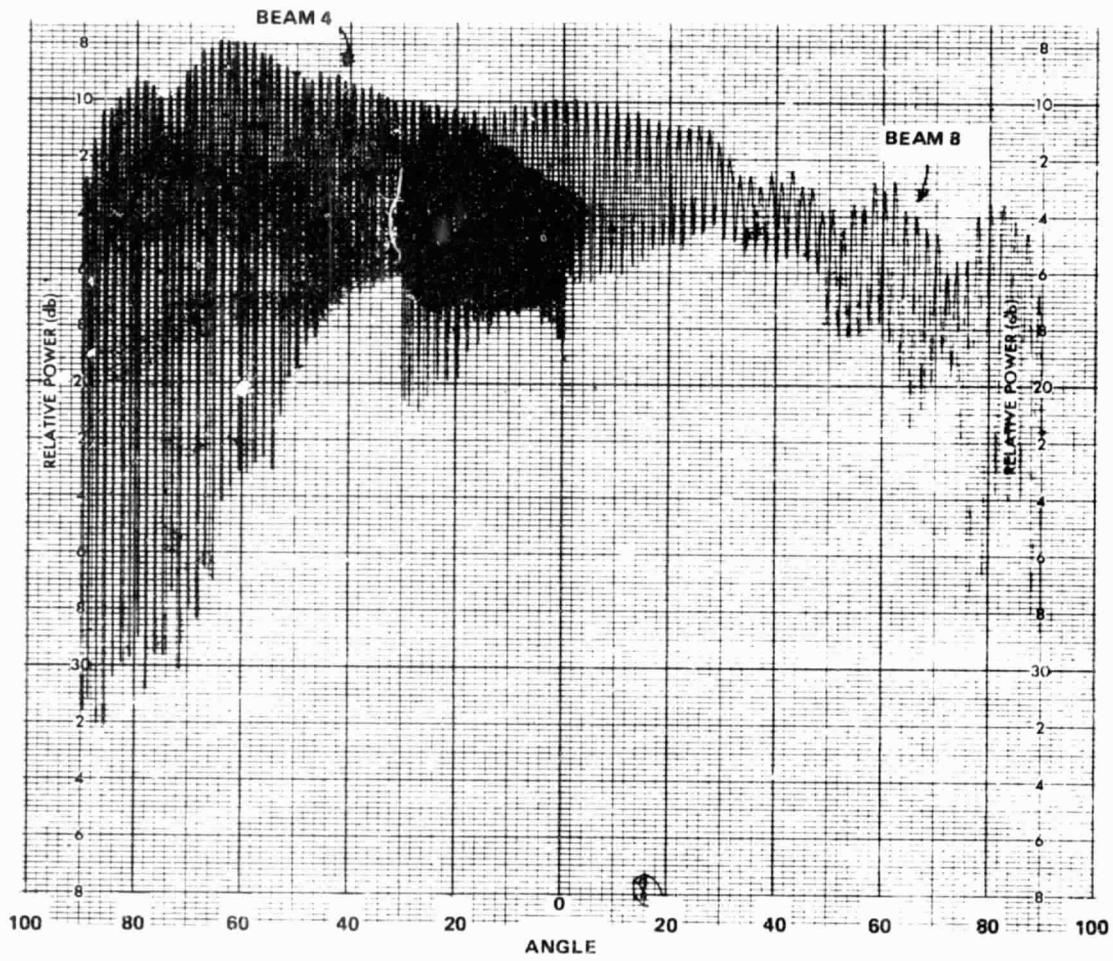
2041.9 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 21.5° DOWN

LOWER ANTENNA



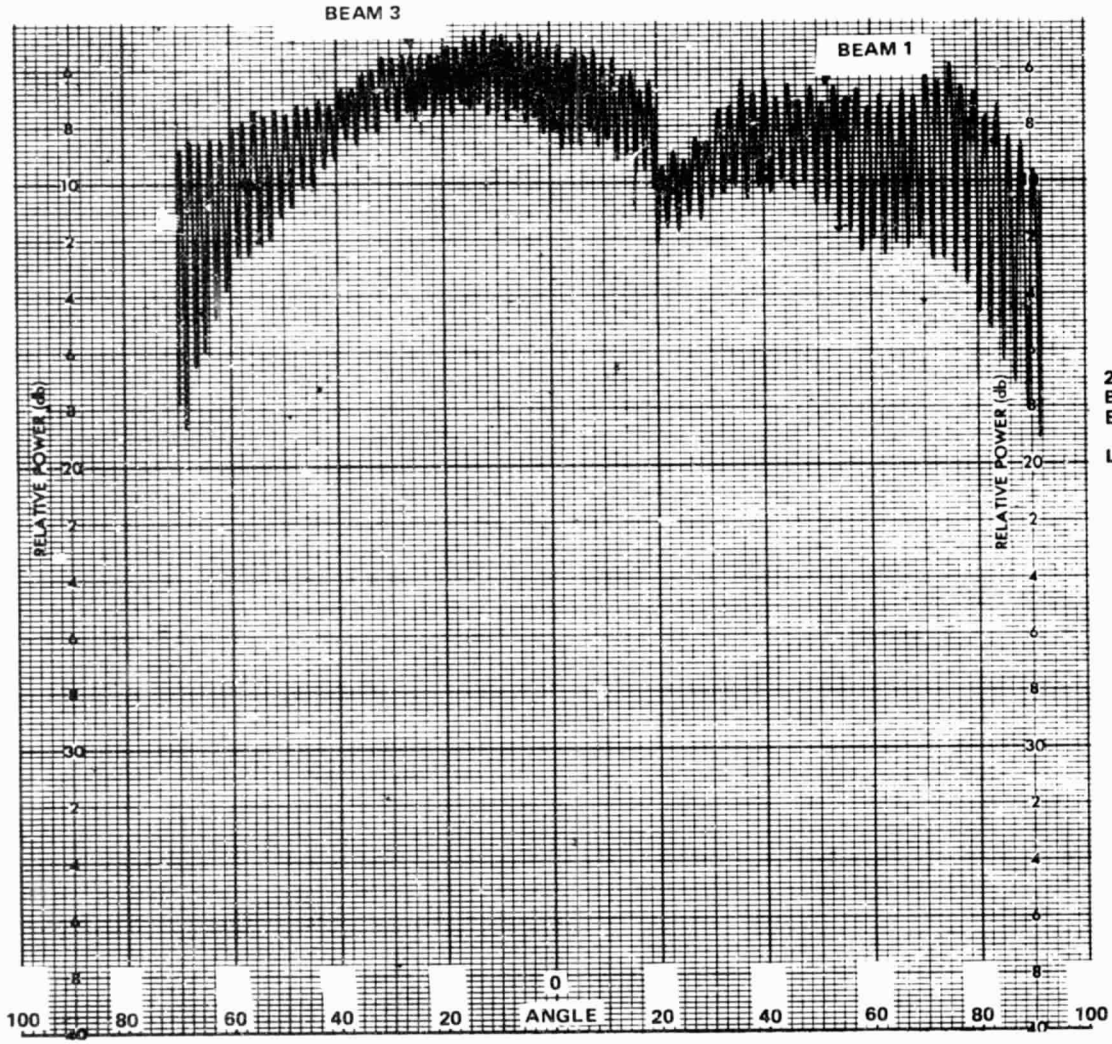
2041.9 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 17.5° UP

LOWER ANTENNA



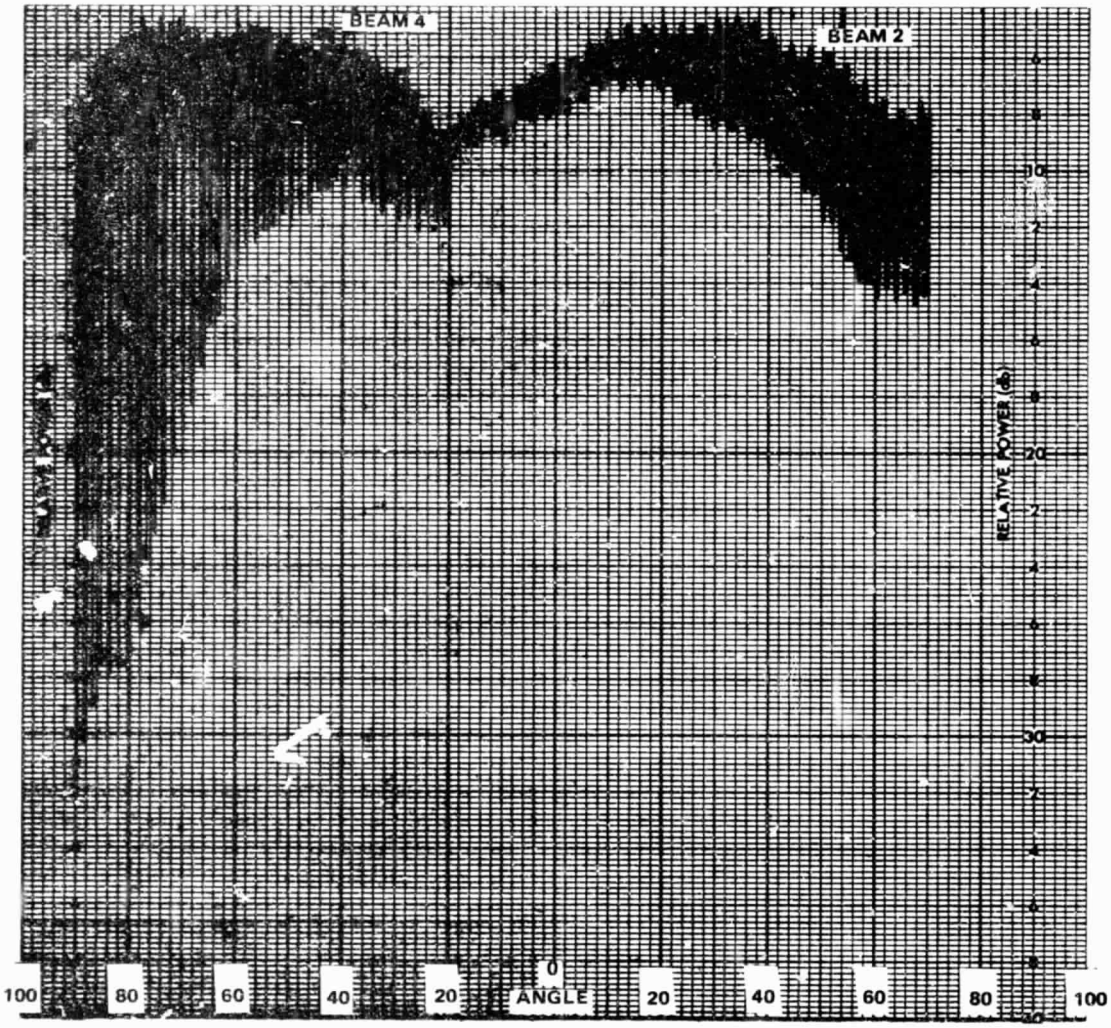
2041.9 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 53.0° UP

LOWER ANTENNA



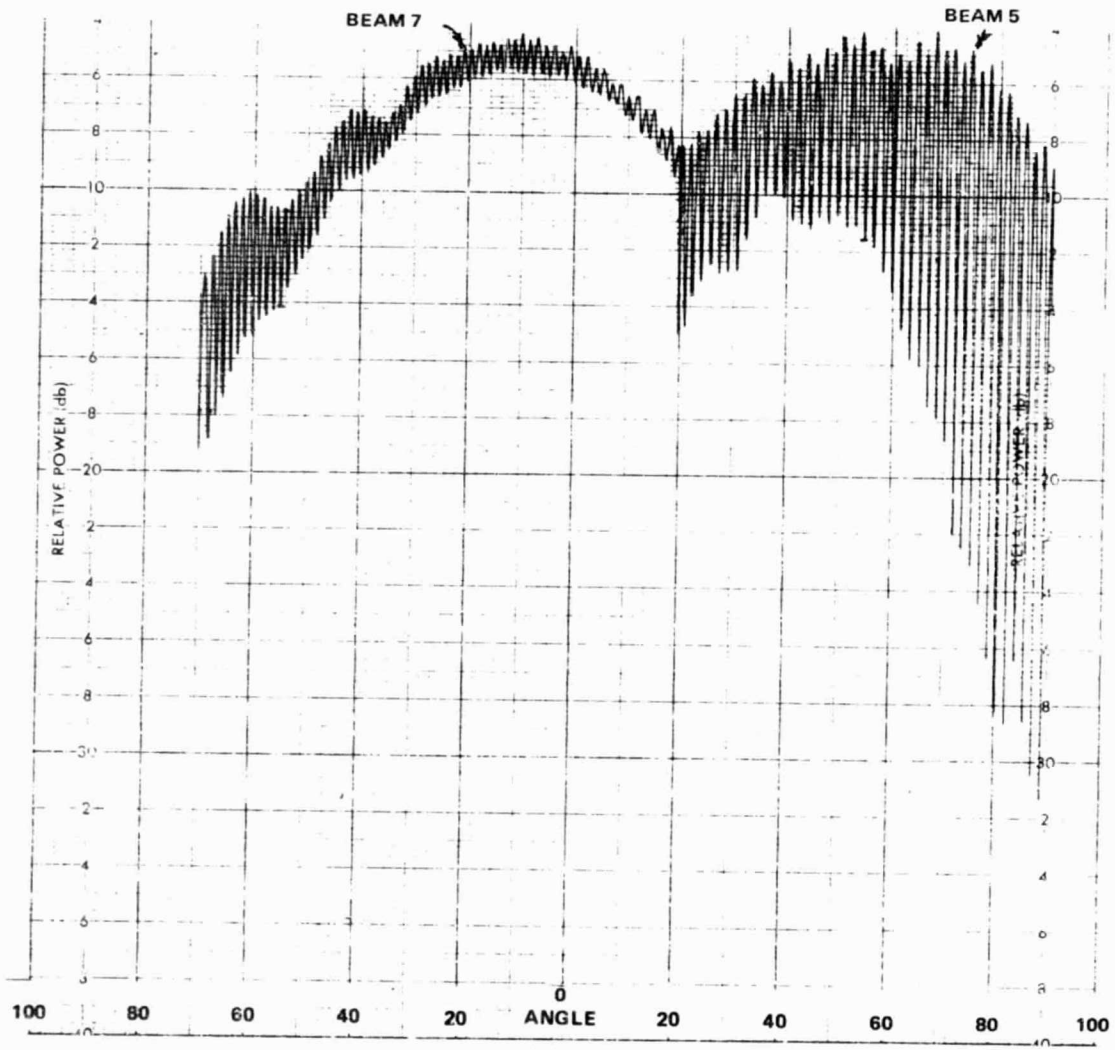
2106.4 MHz
BEAMS 1 AND 3 (PITCH)
ELEVATION: 40.0° DOWN

LOWER ANTENNA



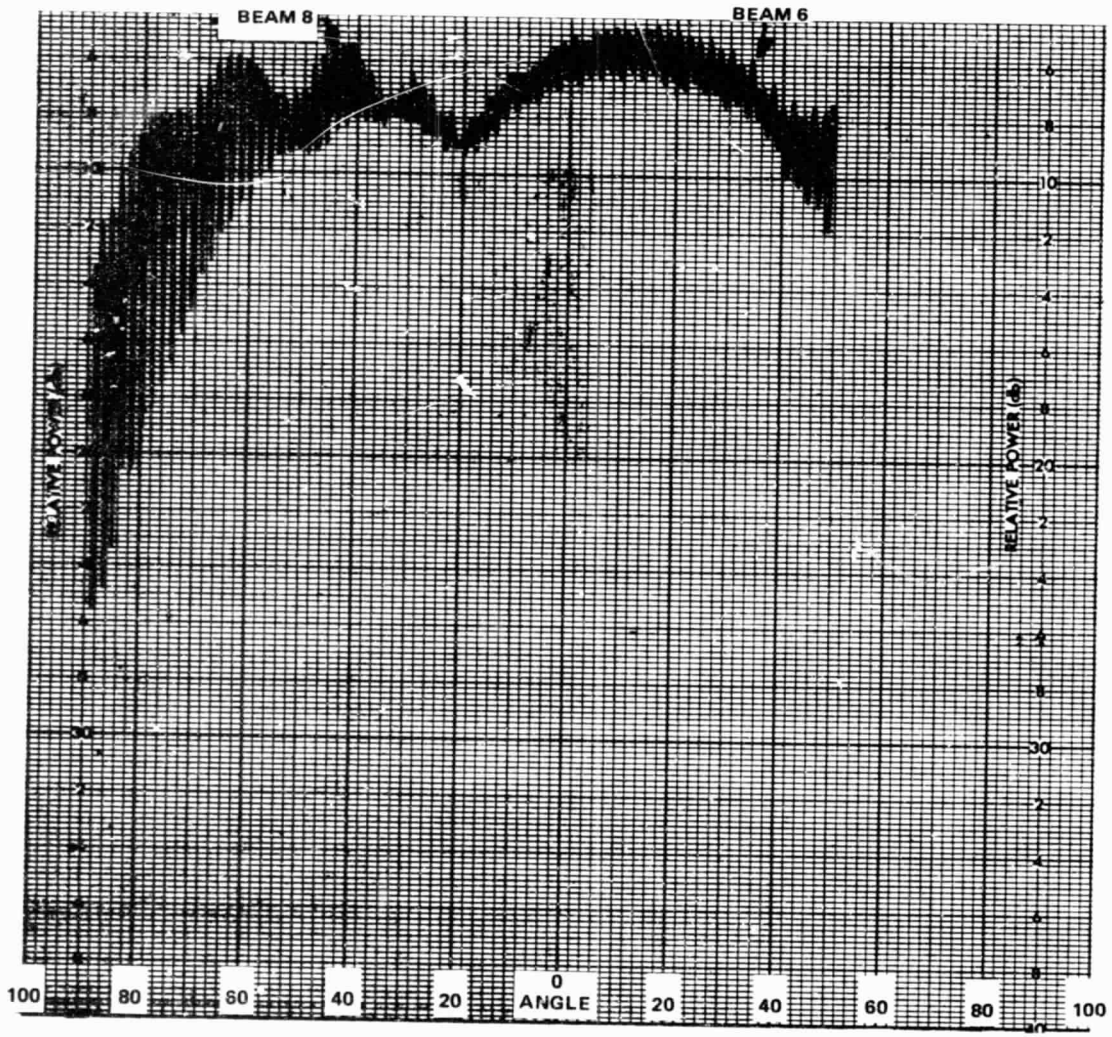
2106.4 MHz
BEAMS 2 AND 4 (PITCH)
ELEVATION: 40.0° DOWN

LOWER ANTENNA



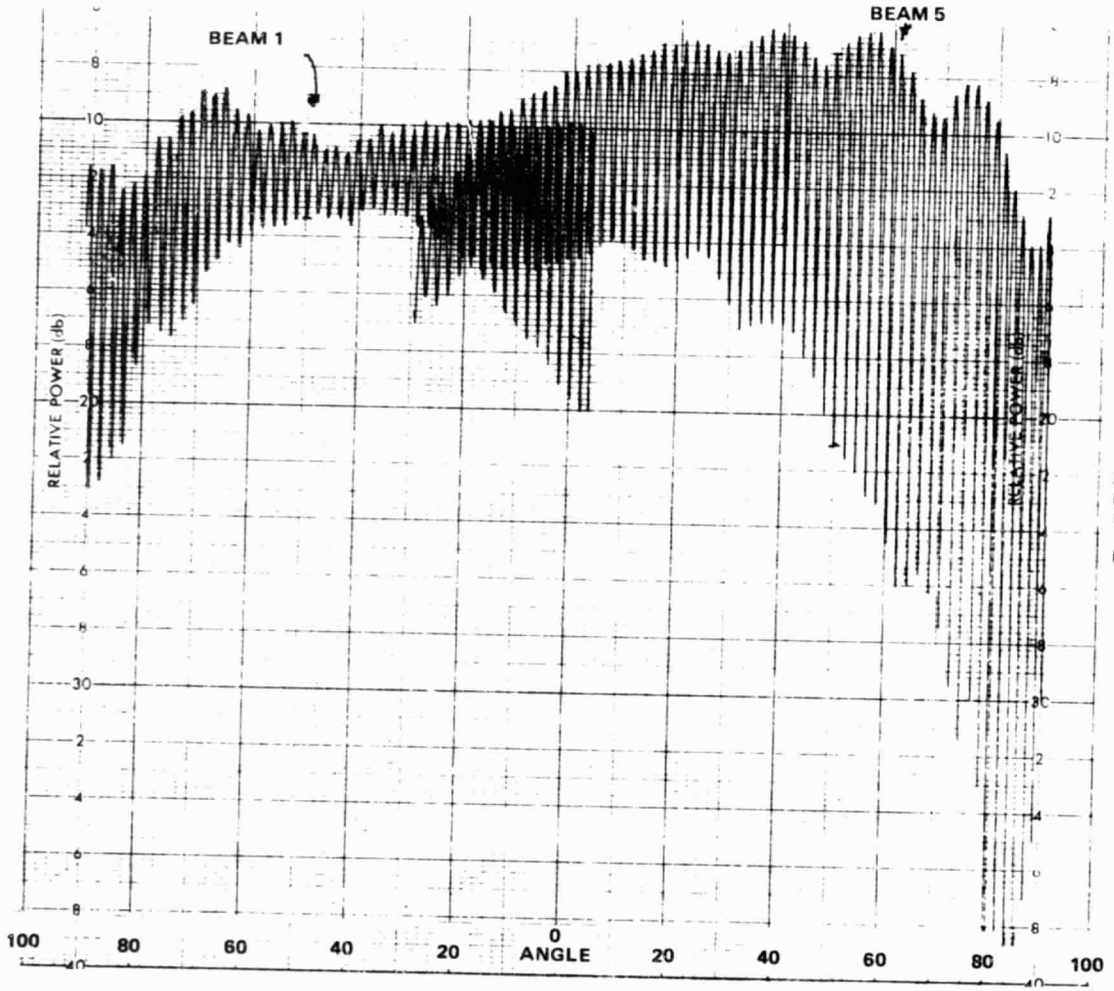
2106.4 MHz
BEAMS 5 AND 7 (PITCH)
ELEVATION: 20.5° UP

LOWER ANTENNA



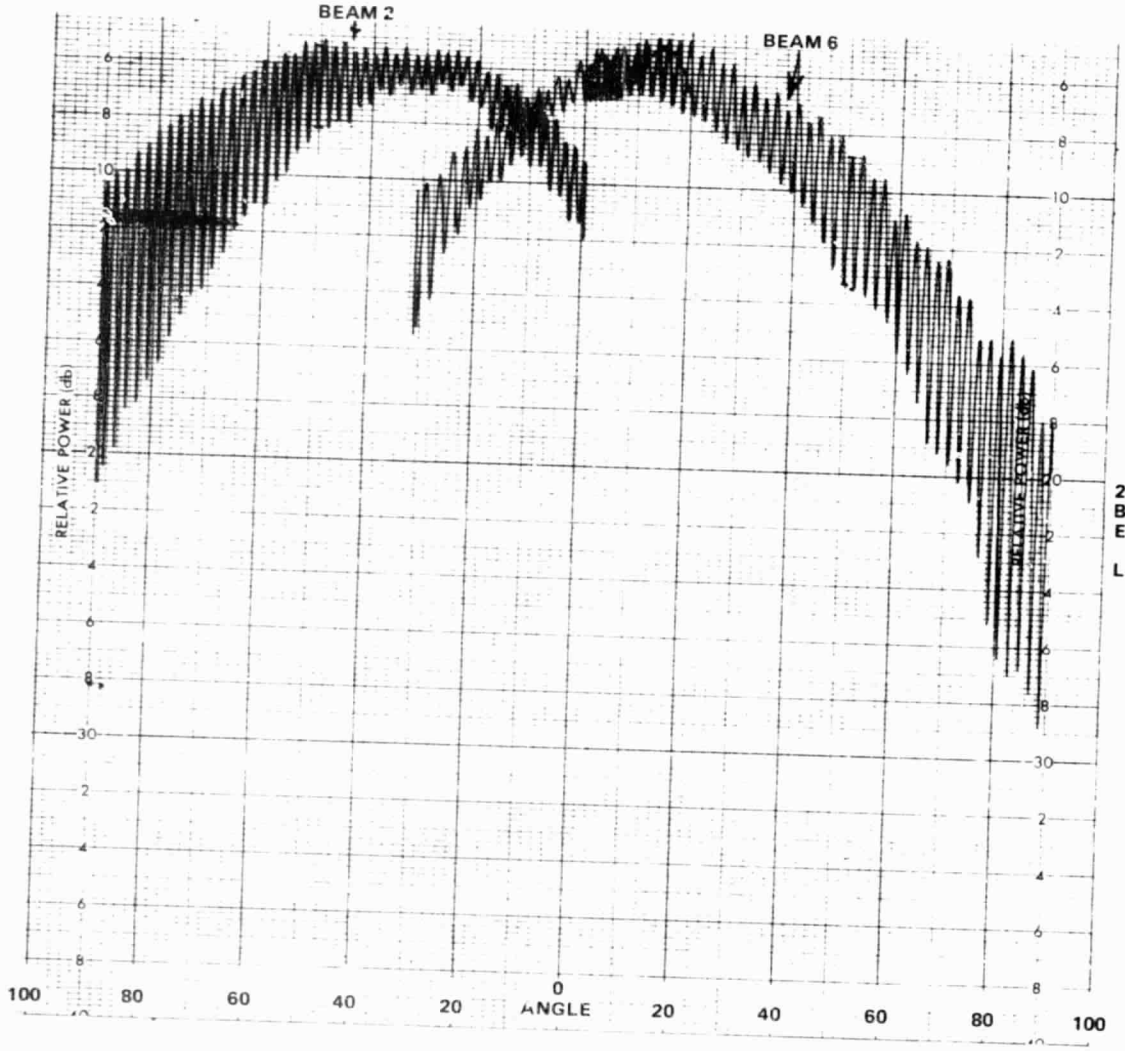
2105.4 MHz
BEAMS 6 AND 8 (PITCH)
ELEVATION: 20.5° UP

LOWER ANTENNA



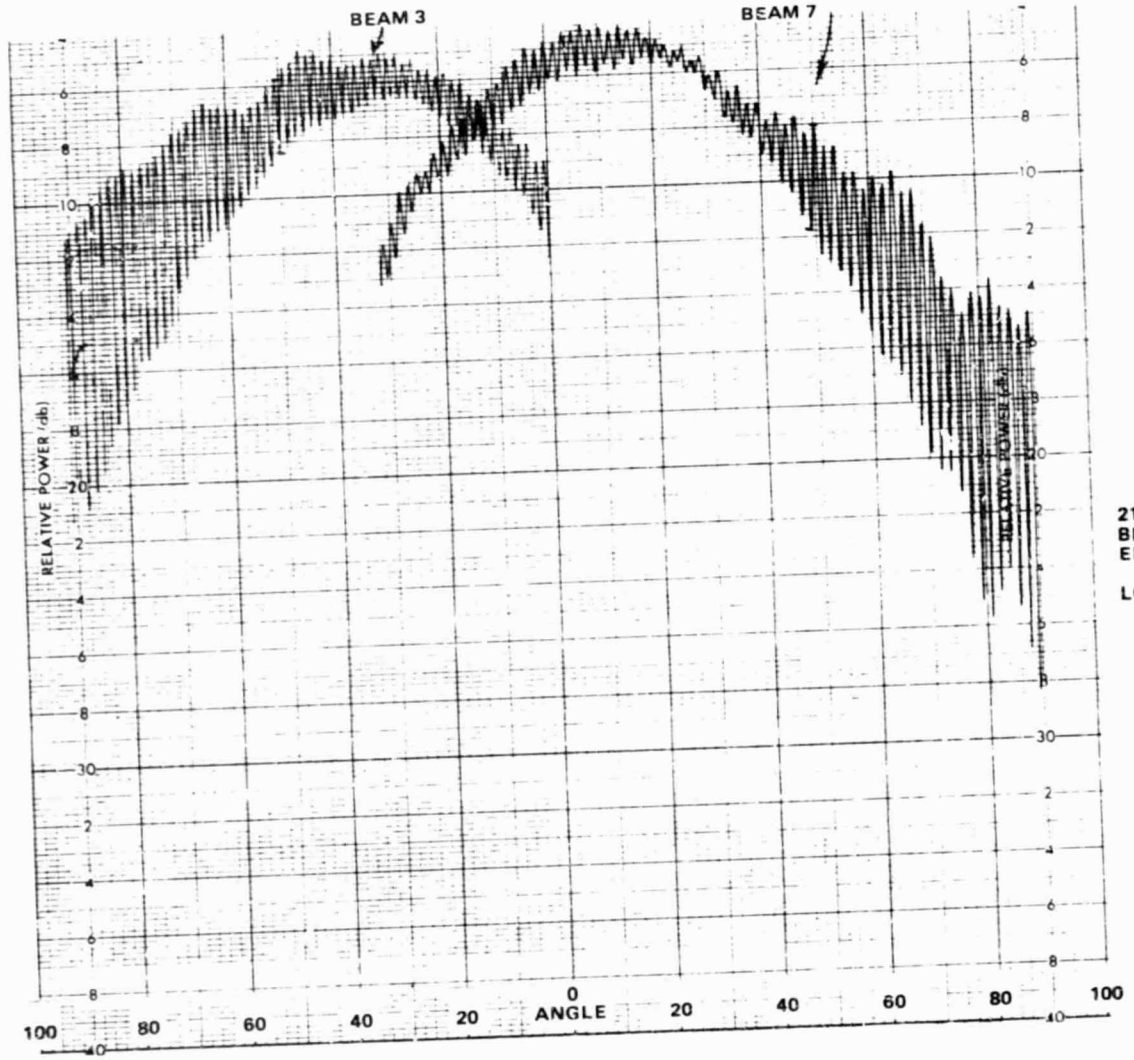
2106.4 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 57.0° DOWN

LOWER ANTENNA



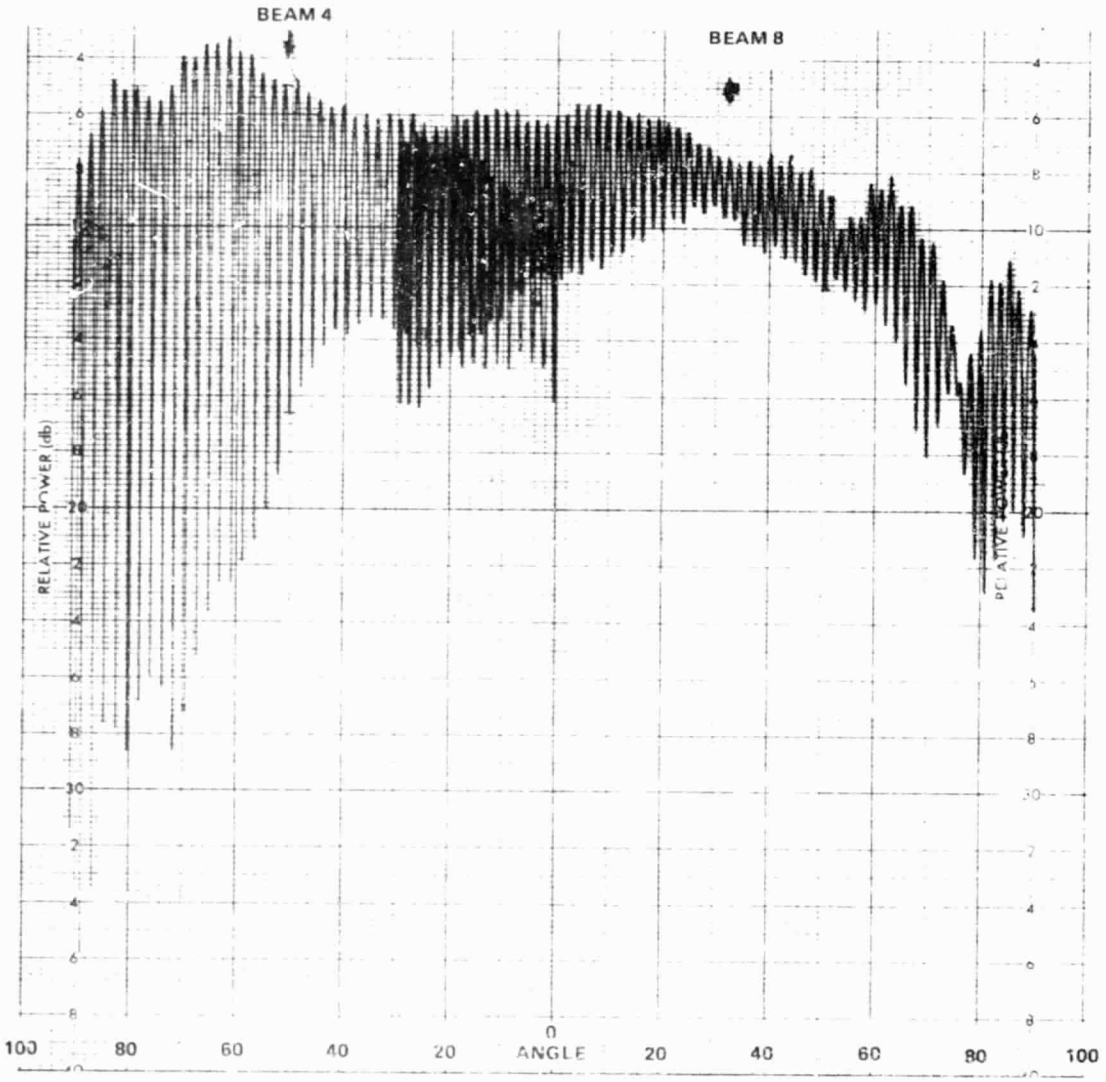
2106.4 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 19.0° DOWN

LOWER ANTENNA



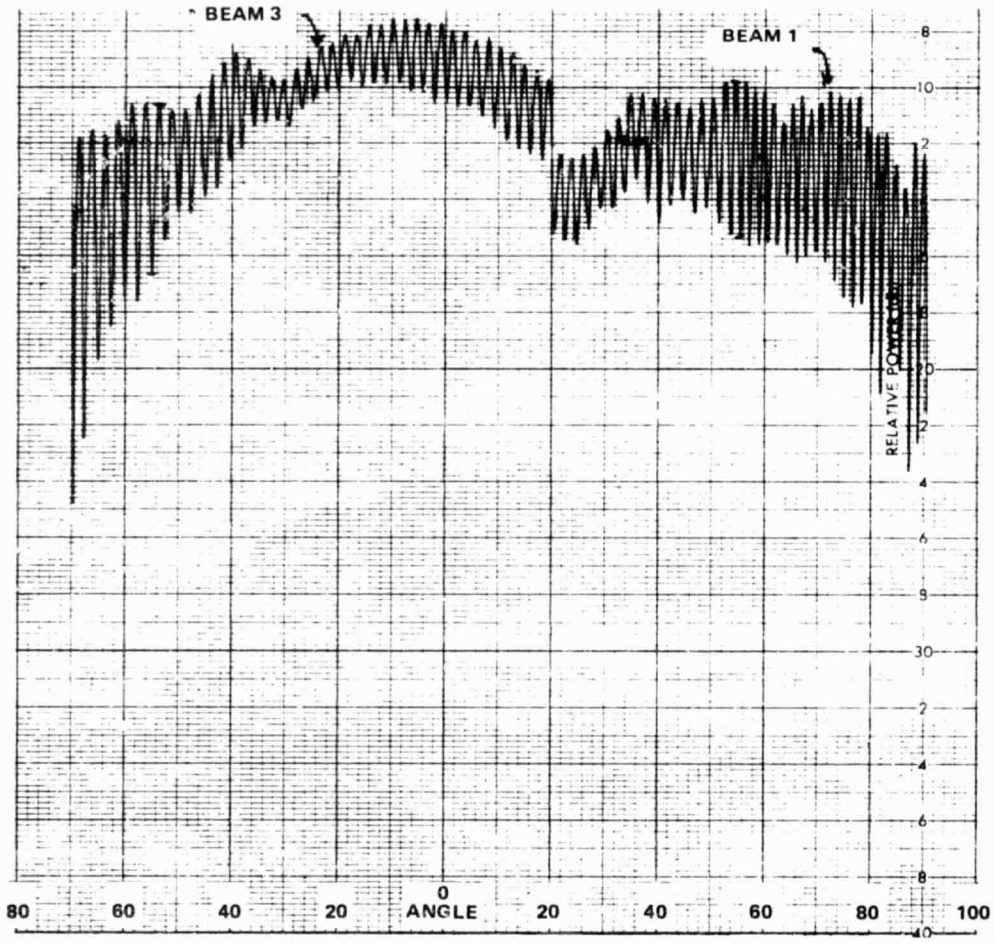
2106.4 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 18.0° UP

LOWER ANTENNA



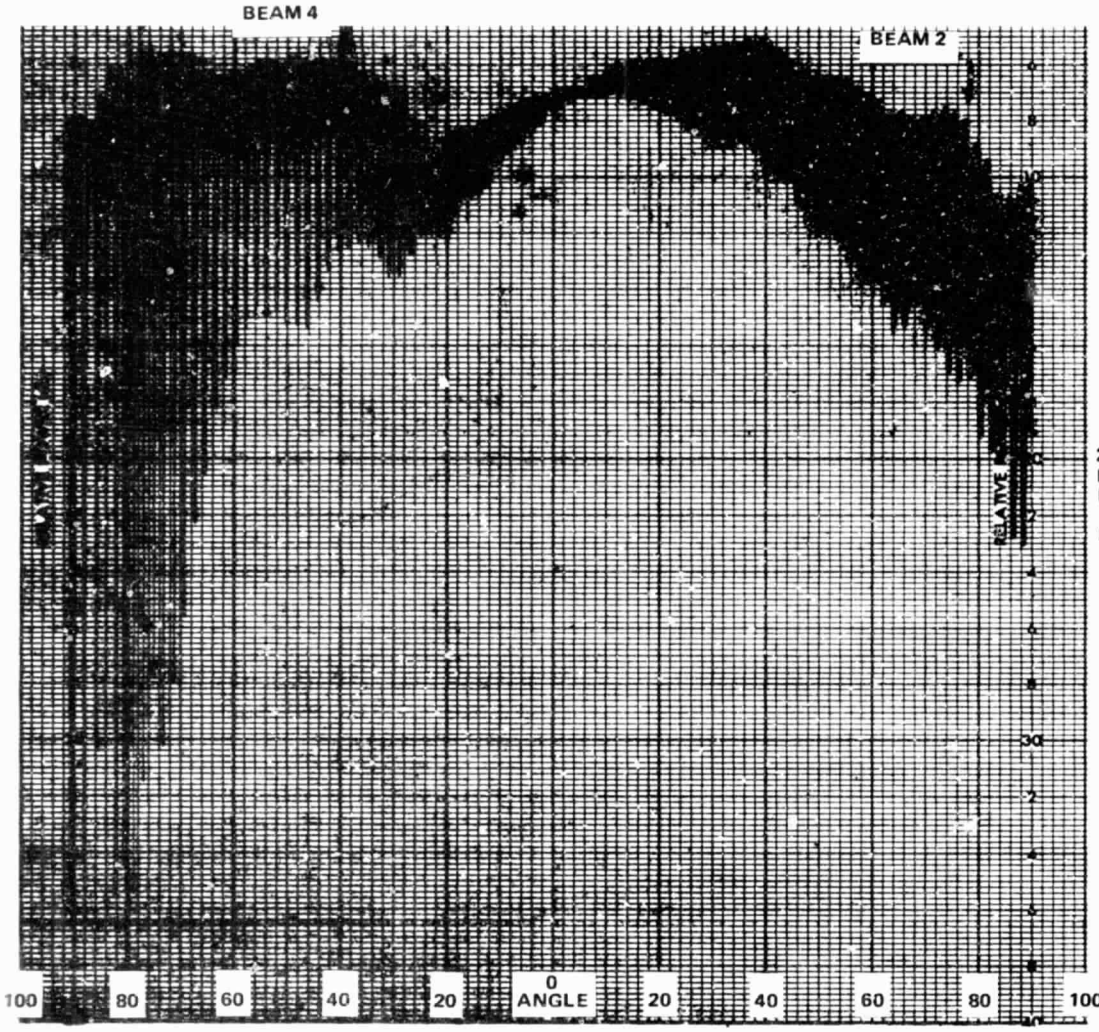
2106.4 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 54.0° UP

LOWER ANTENNA



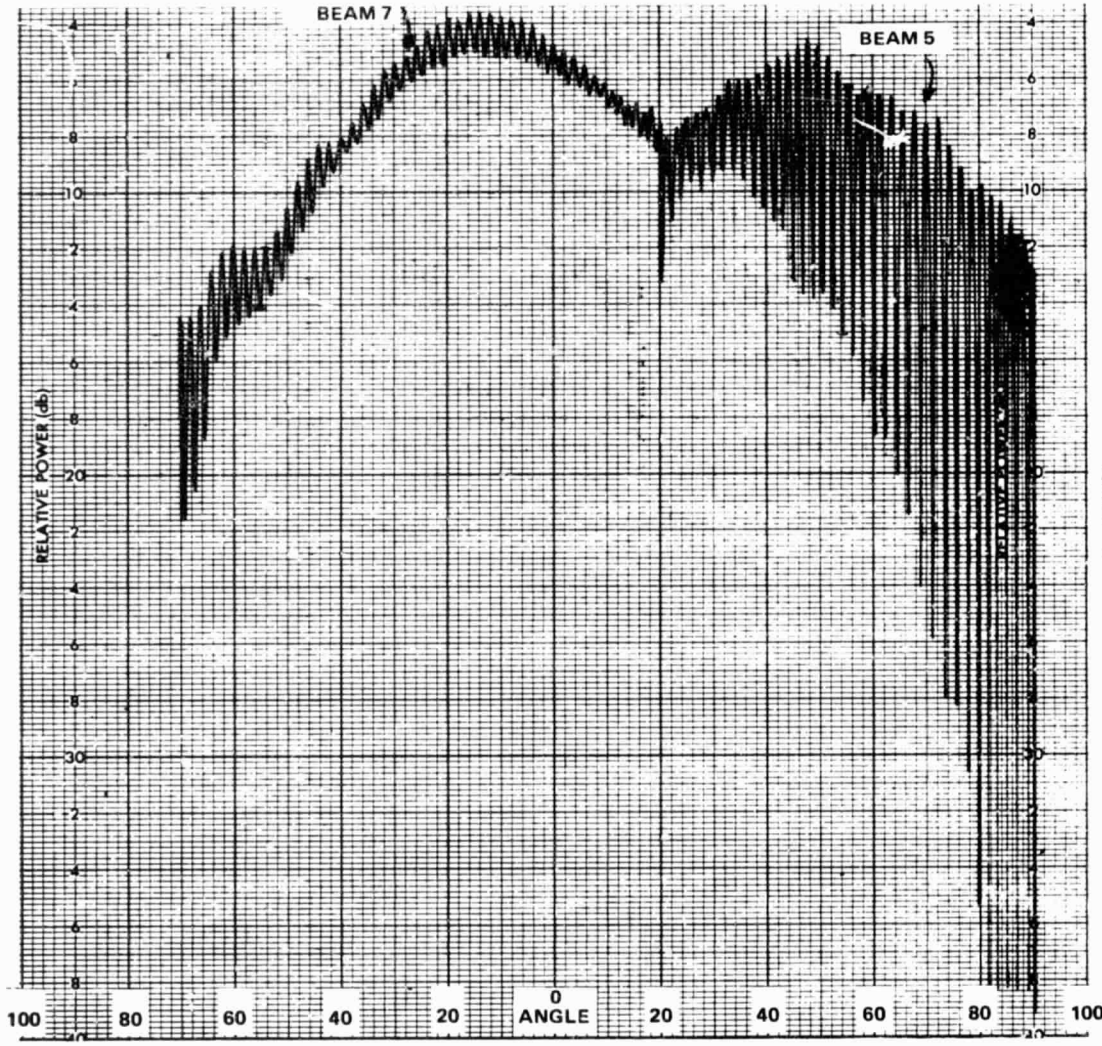
2217.5 MHz
BEAMS 1 AND 3 (PITCH)
ELEVATION: 46.0° DOWN

LOWER ANTENNA



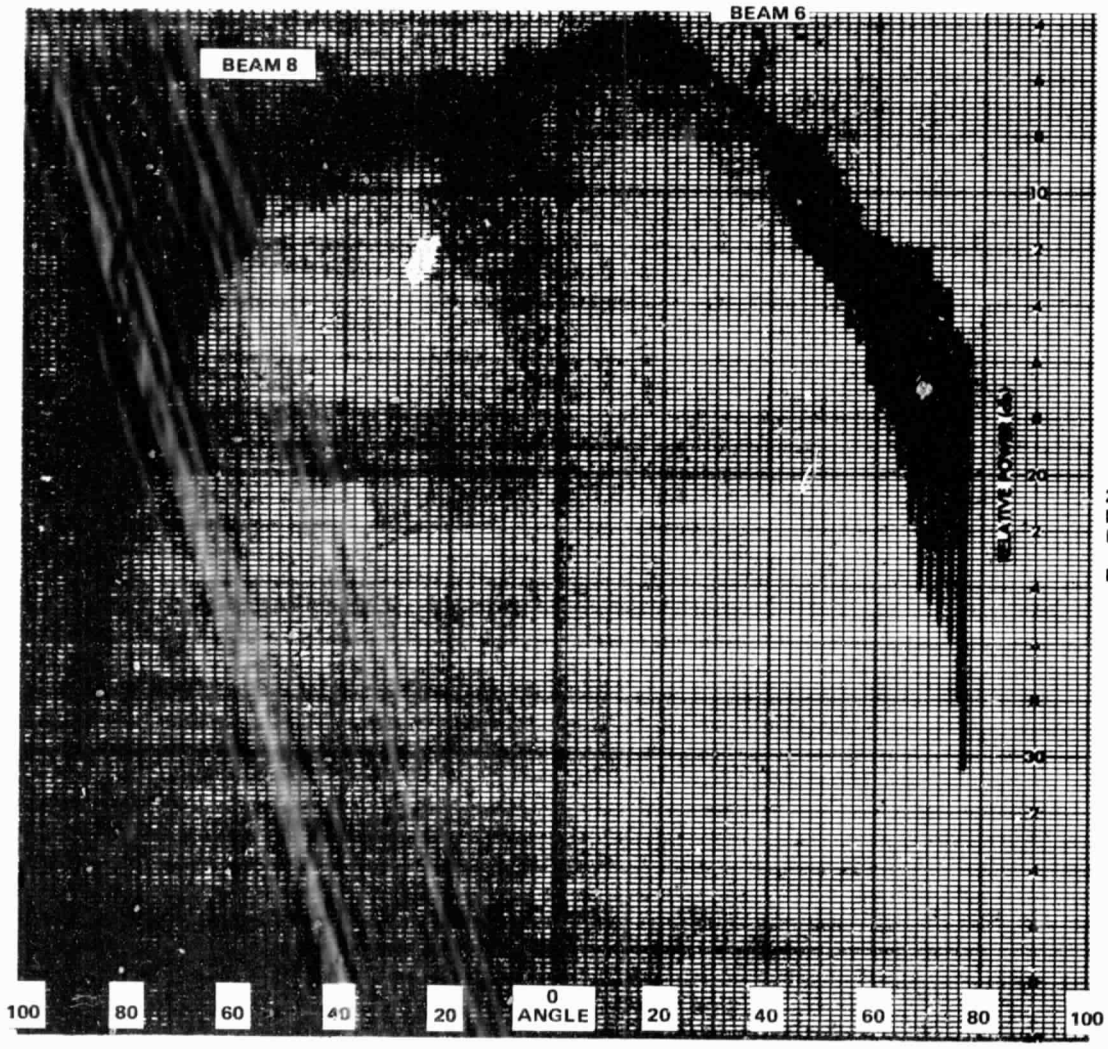
2217.5 MHz
BEAMS 2 AND 4 (PITCH)
ELEVATION: 46.0° DOWN

LOWER ANTENNA



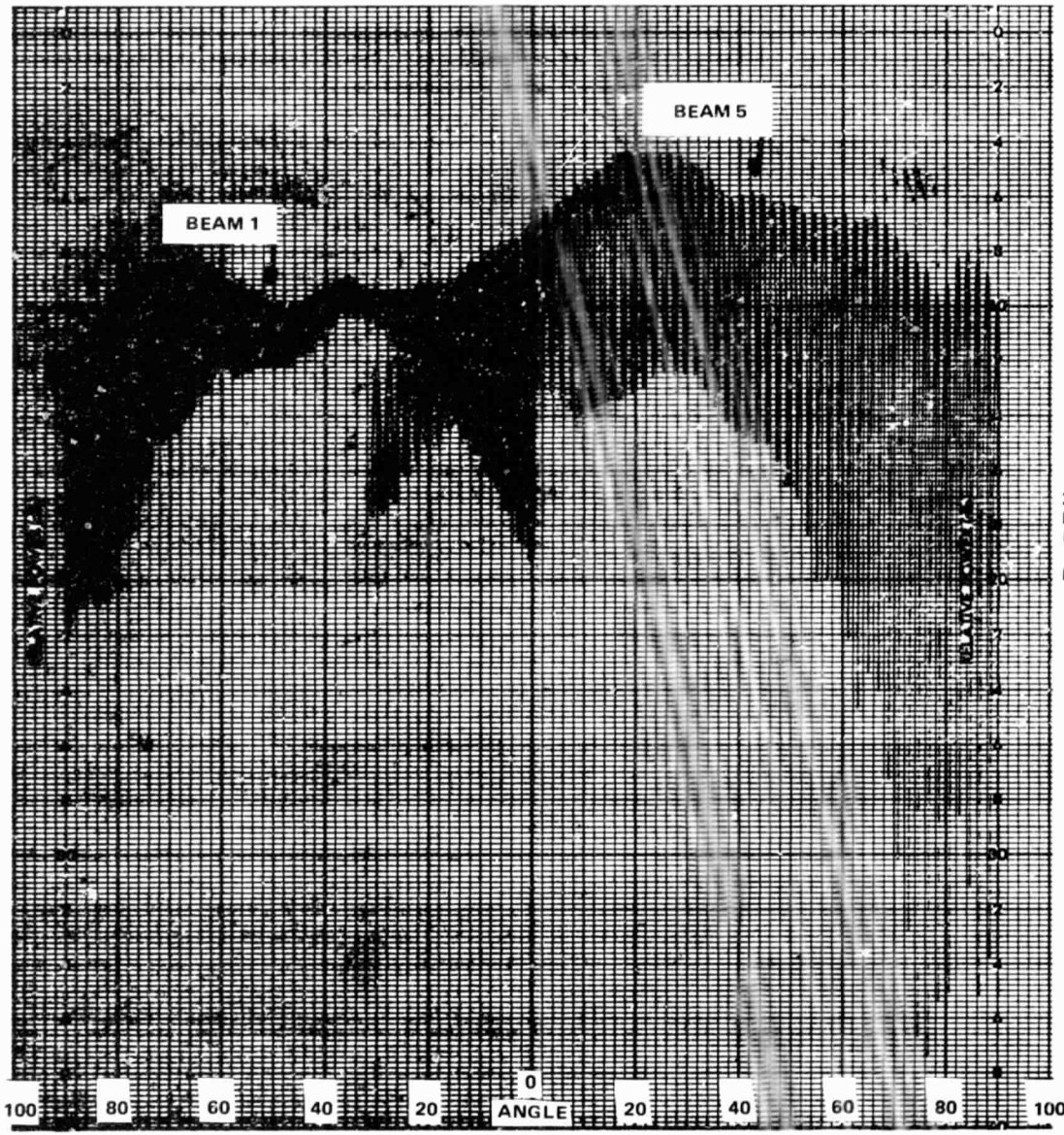
2217.5 MHz
BEAMS 5 AND 7 (PITCH)
ELEVATION: 14.5° UP

LOWER ANTENNA



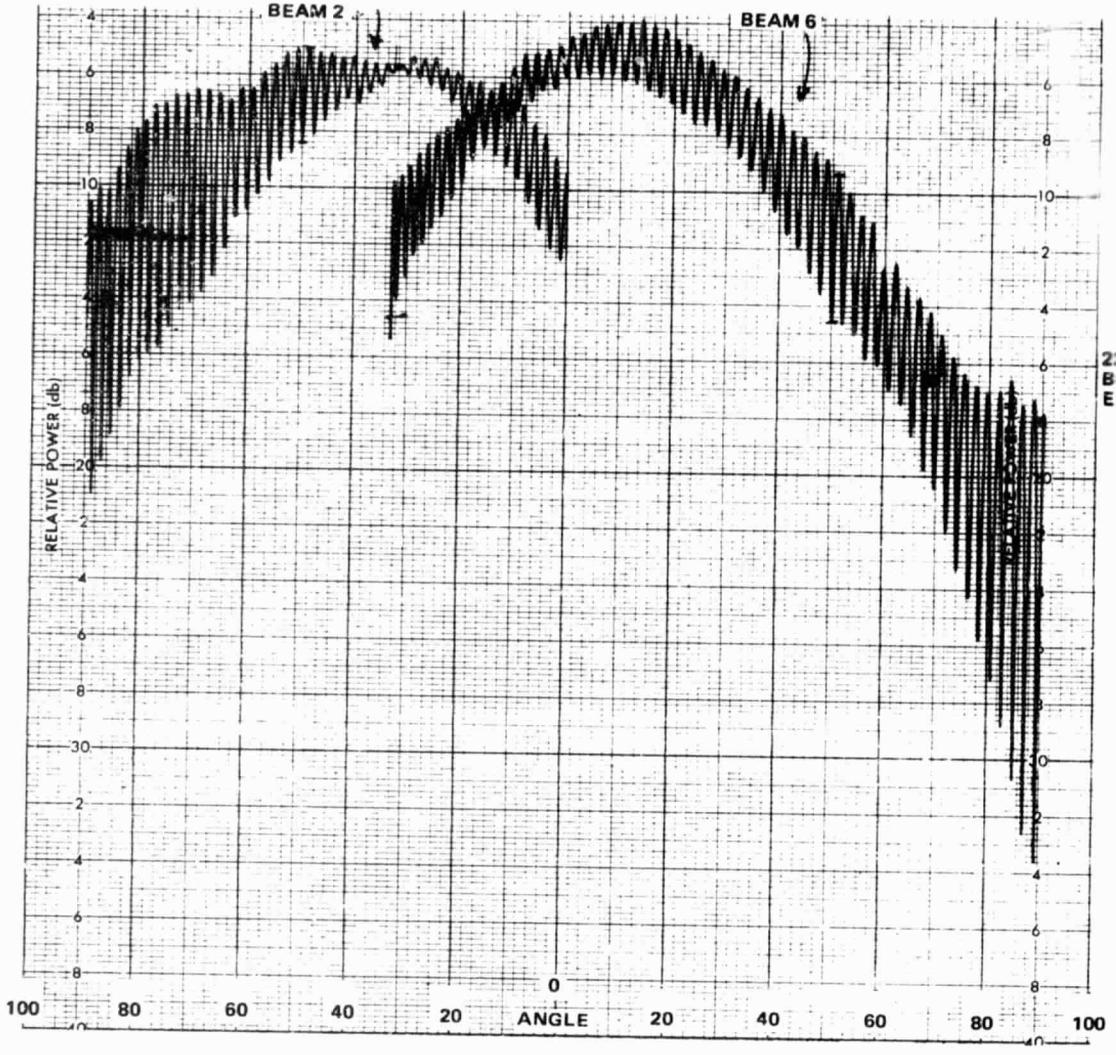
2217.5 MHz
BEAMS 6 AND 8 (PITCH)
ELEVATION: 14.5° UP

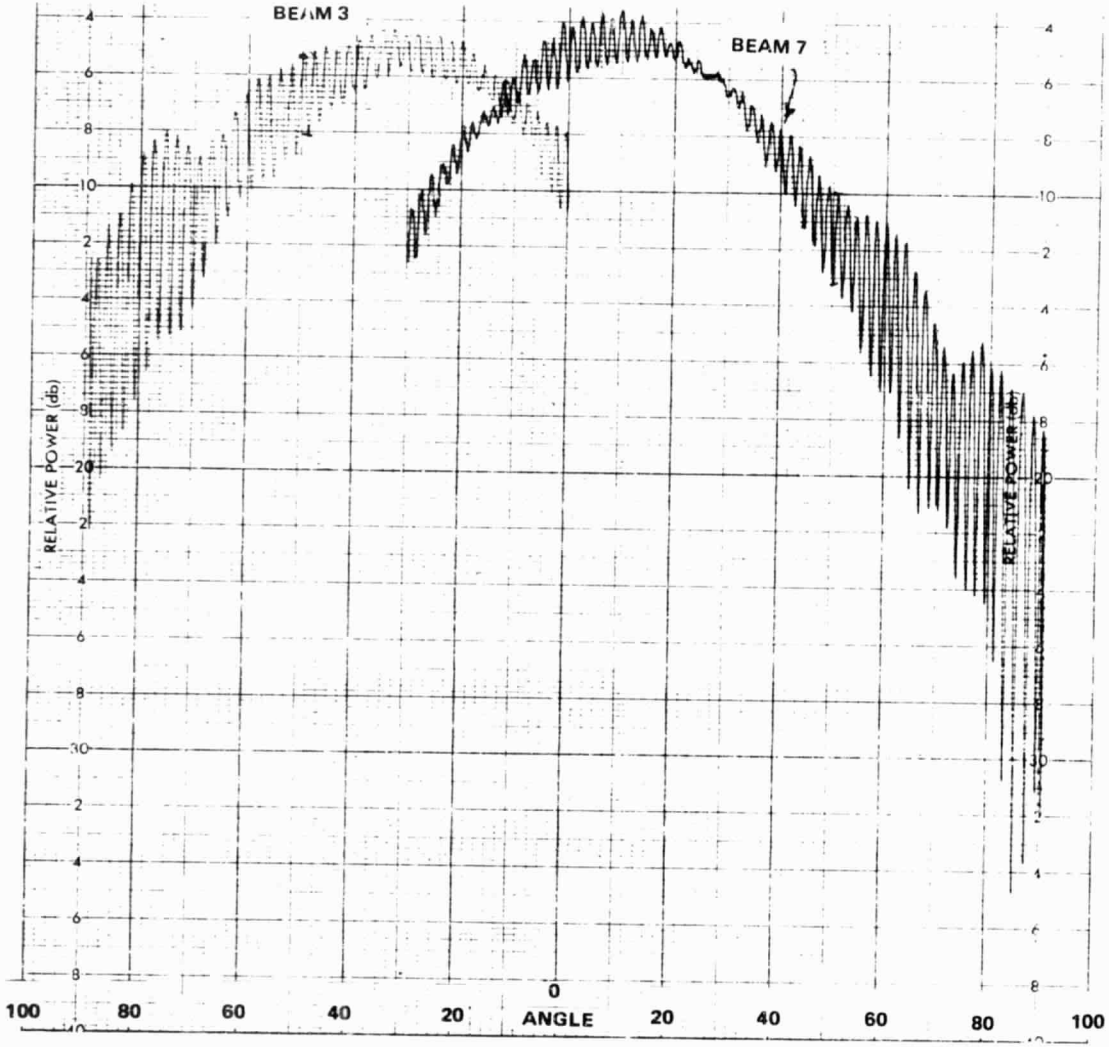
LOWER ANTENNA



2217.5 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 52.5° DOWN

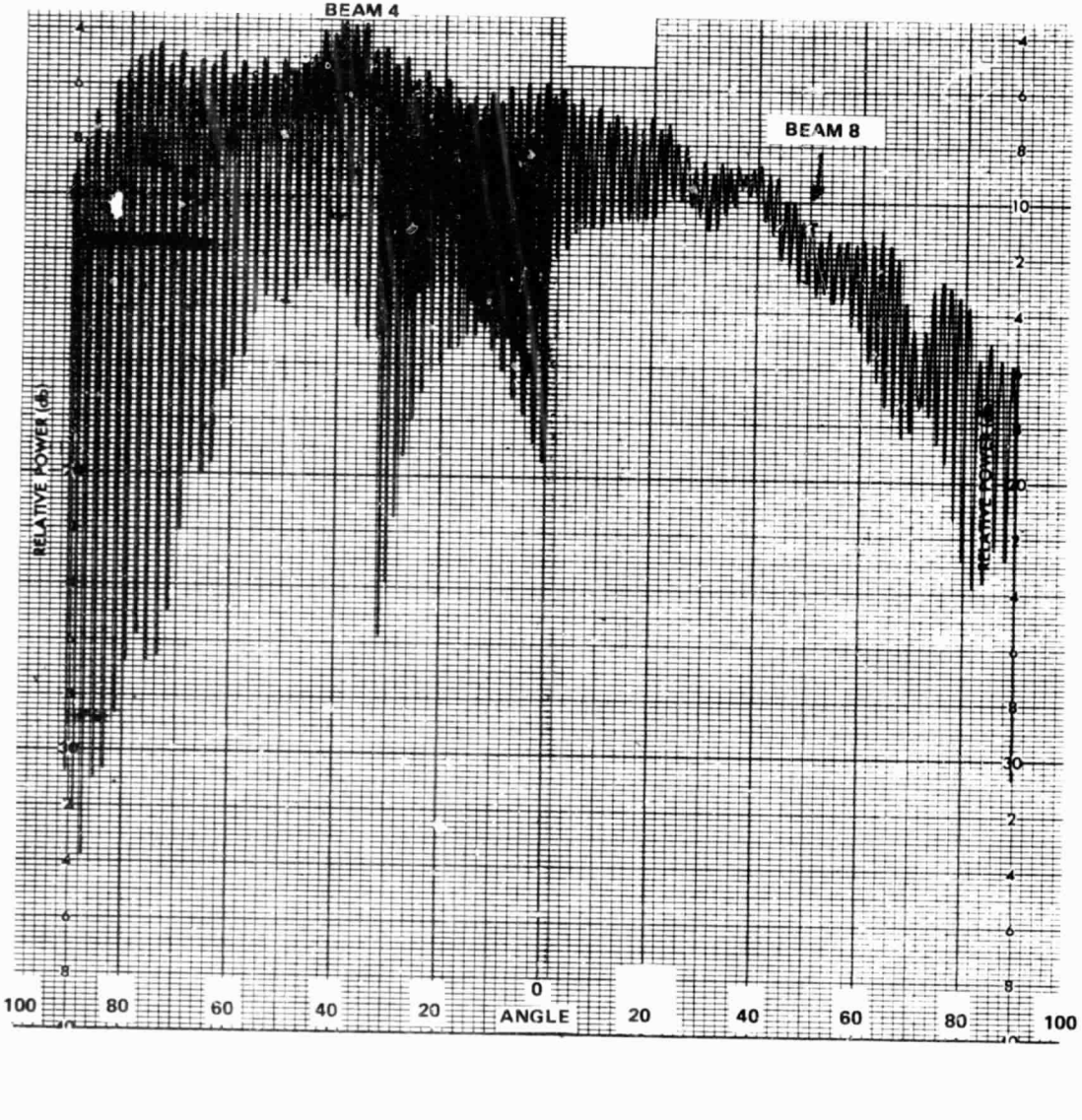
LOWER ANTENNA


BEAM 2
BEAM 6
RELATIVE POWER (db)
ANGLE
100
80
60
40
20
0
20
40
60
80
100
2287.5 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 17.5° DOWN
LOWER ANTENNA



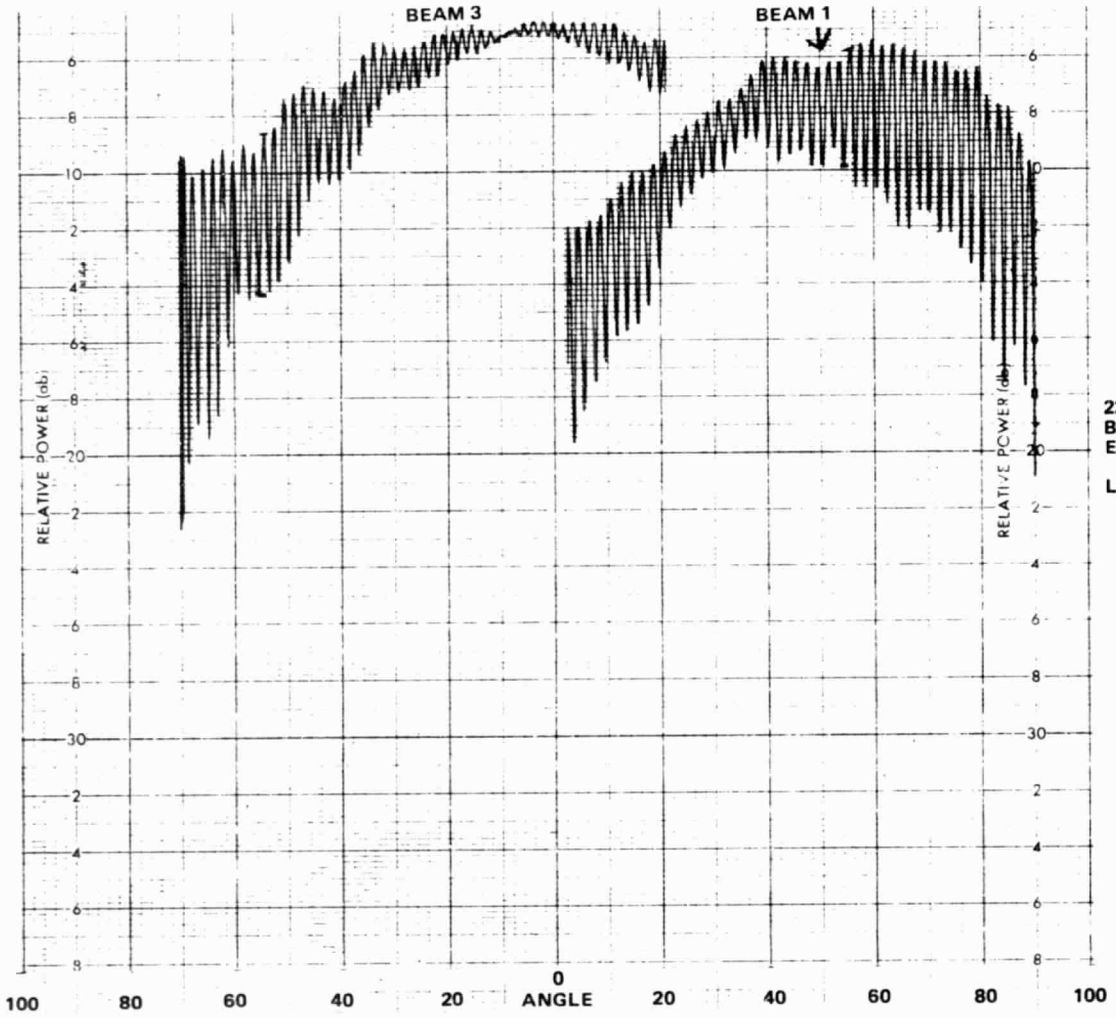
2217.5 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 13.5° UP

LOWER ANTENNA



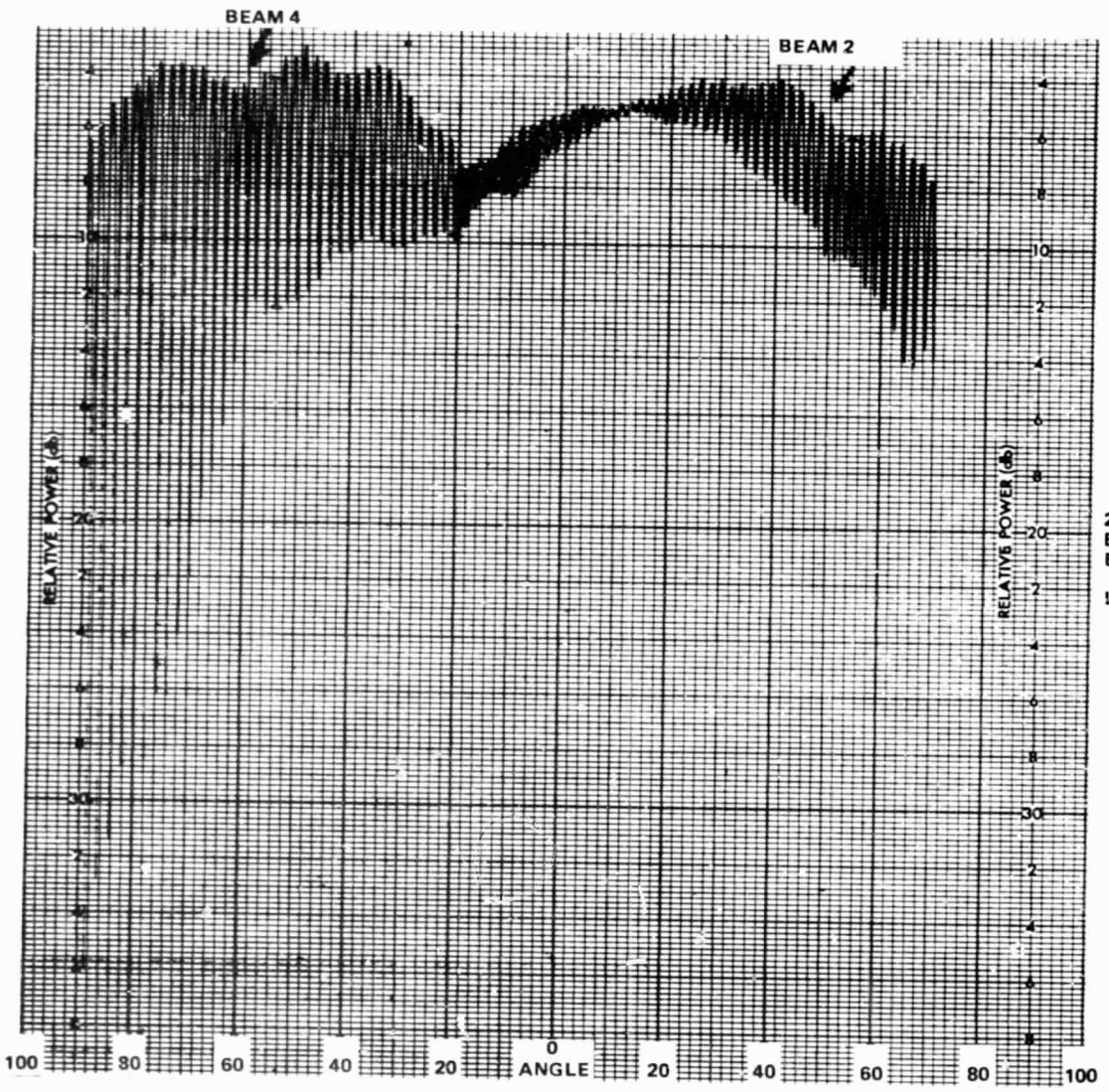
2217.5 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 48.5° UP

LOWER ANTENNA



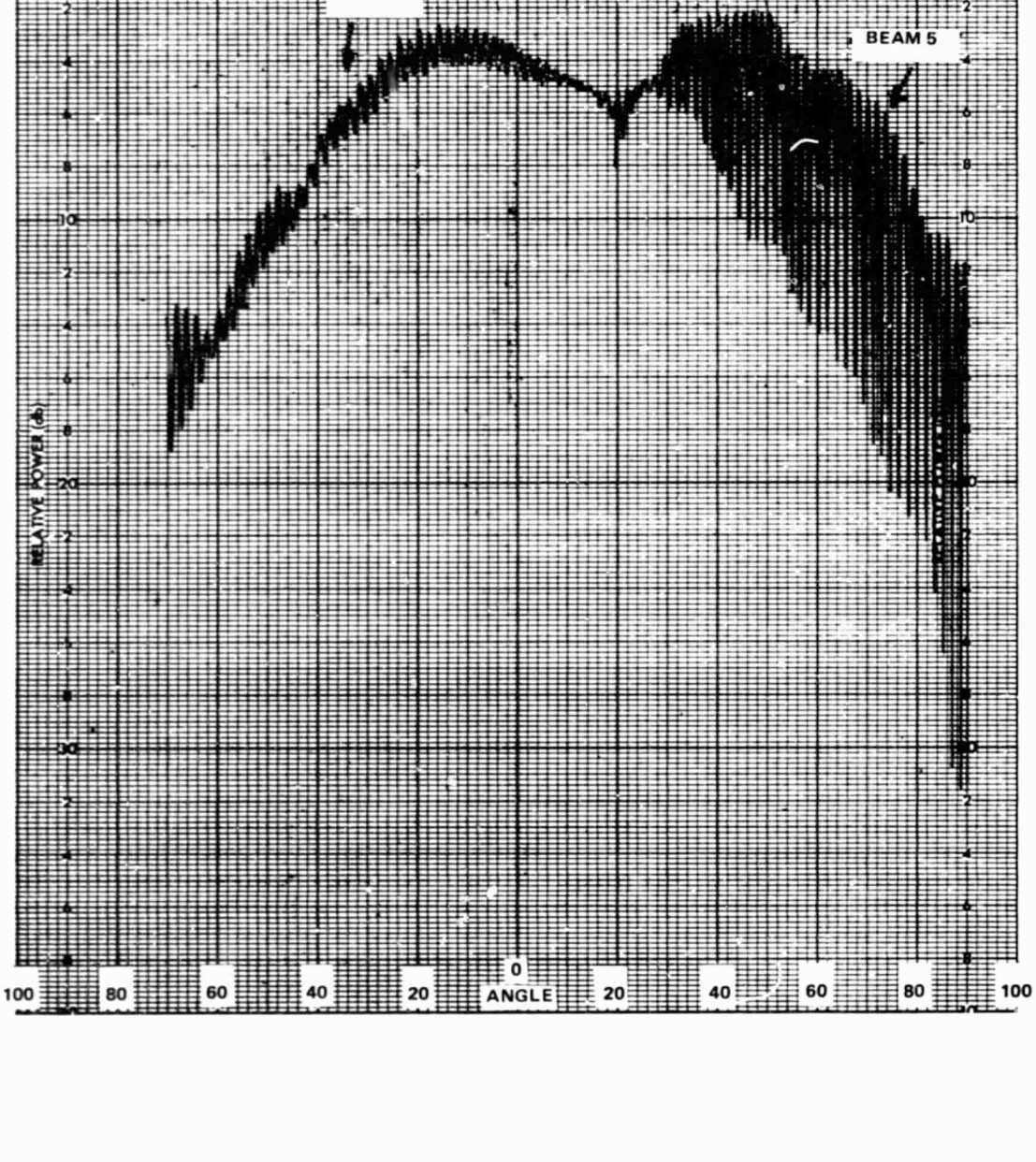
2287.5 MHz
BEAMS 1 AND 3 (PITCH)
ELEVATION: 43.0° DOWN

LOWER ANTENNA



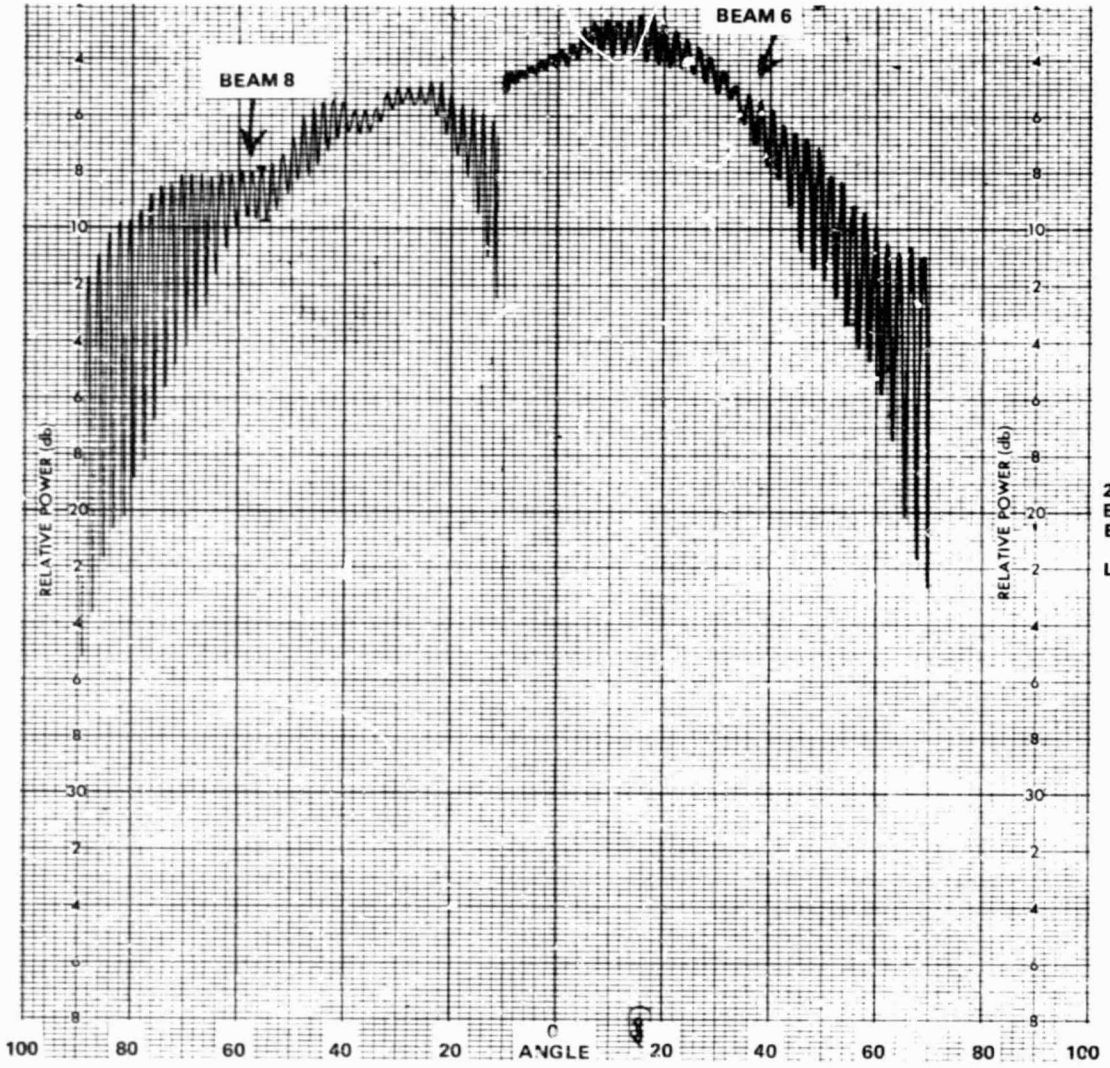
2287.5 MHz
BEAMS 2 AND 4 (PITCH)
ELEVATION: 43.0° DOWN

LOWER ANTENNA



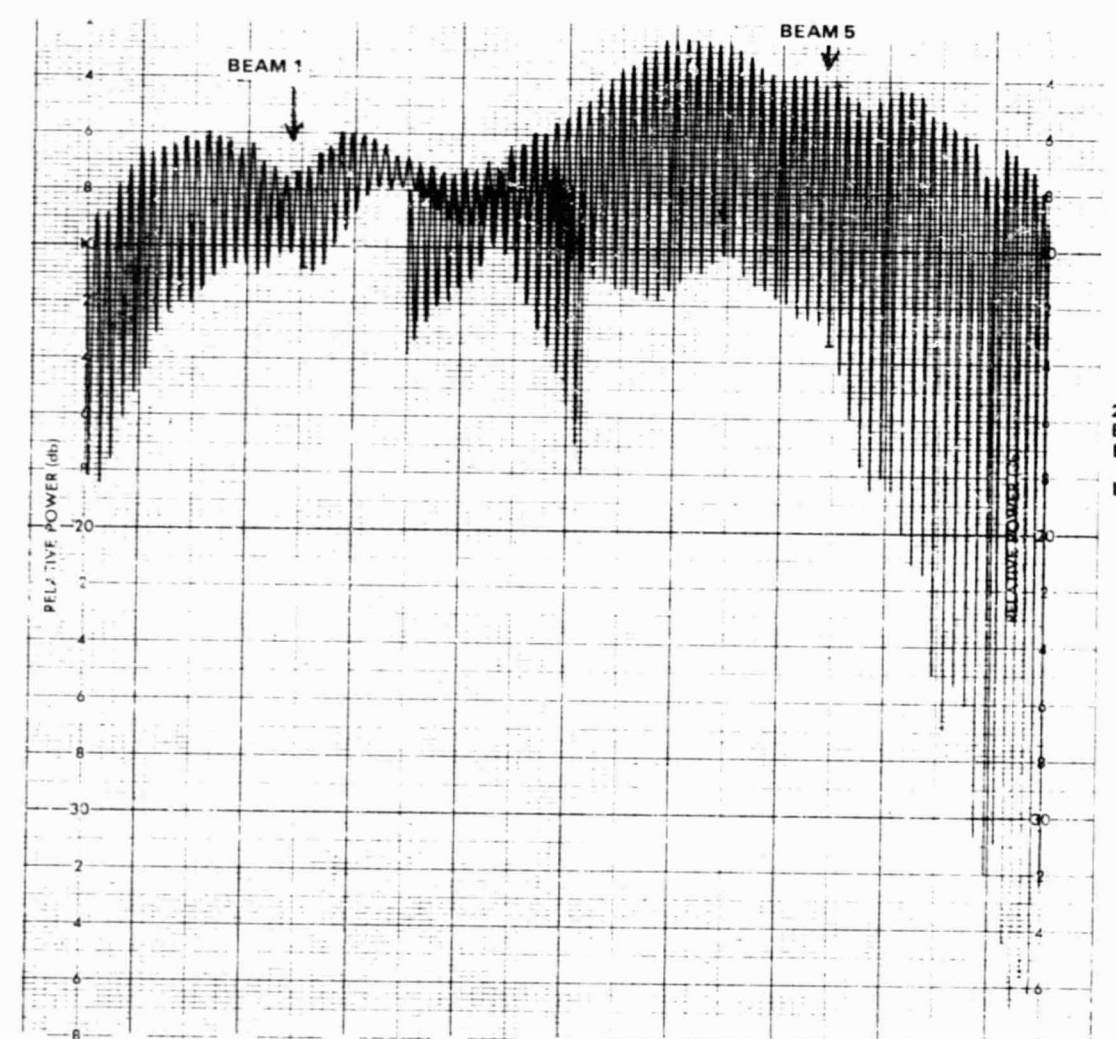
2287.5 MHz
BEAMS 5 AND 7 (PITCH)
ELEVATION: 13.0° UP

LOWER ANTENNA



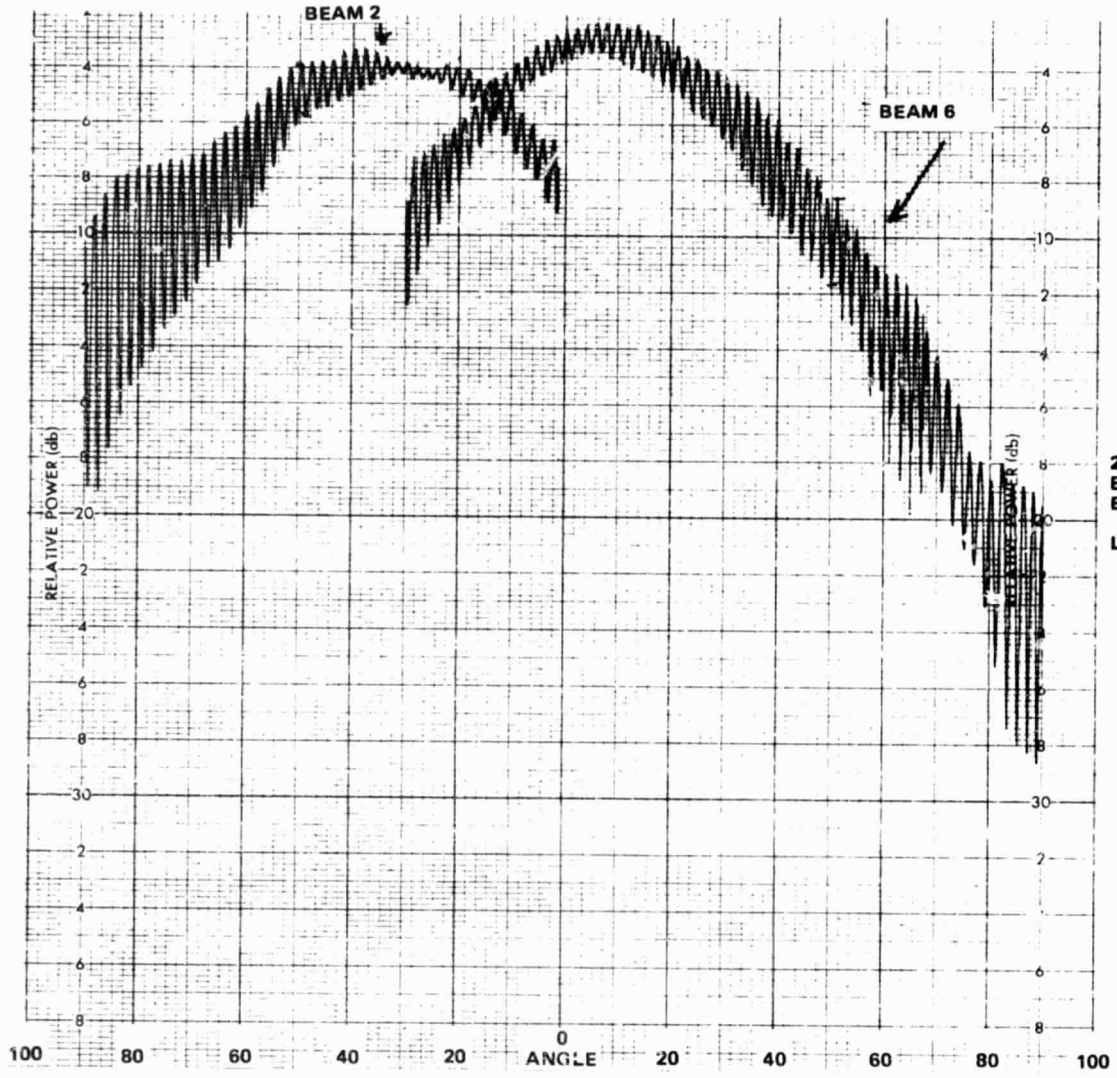
2287.5 MHz
BEAMS 6 AND 8 (PITCH)
ELEVATION: 13.0° UP

LOWER ANTENNA



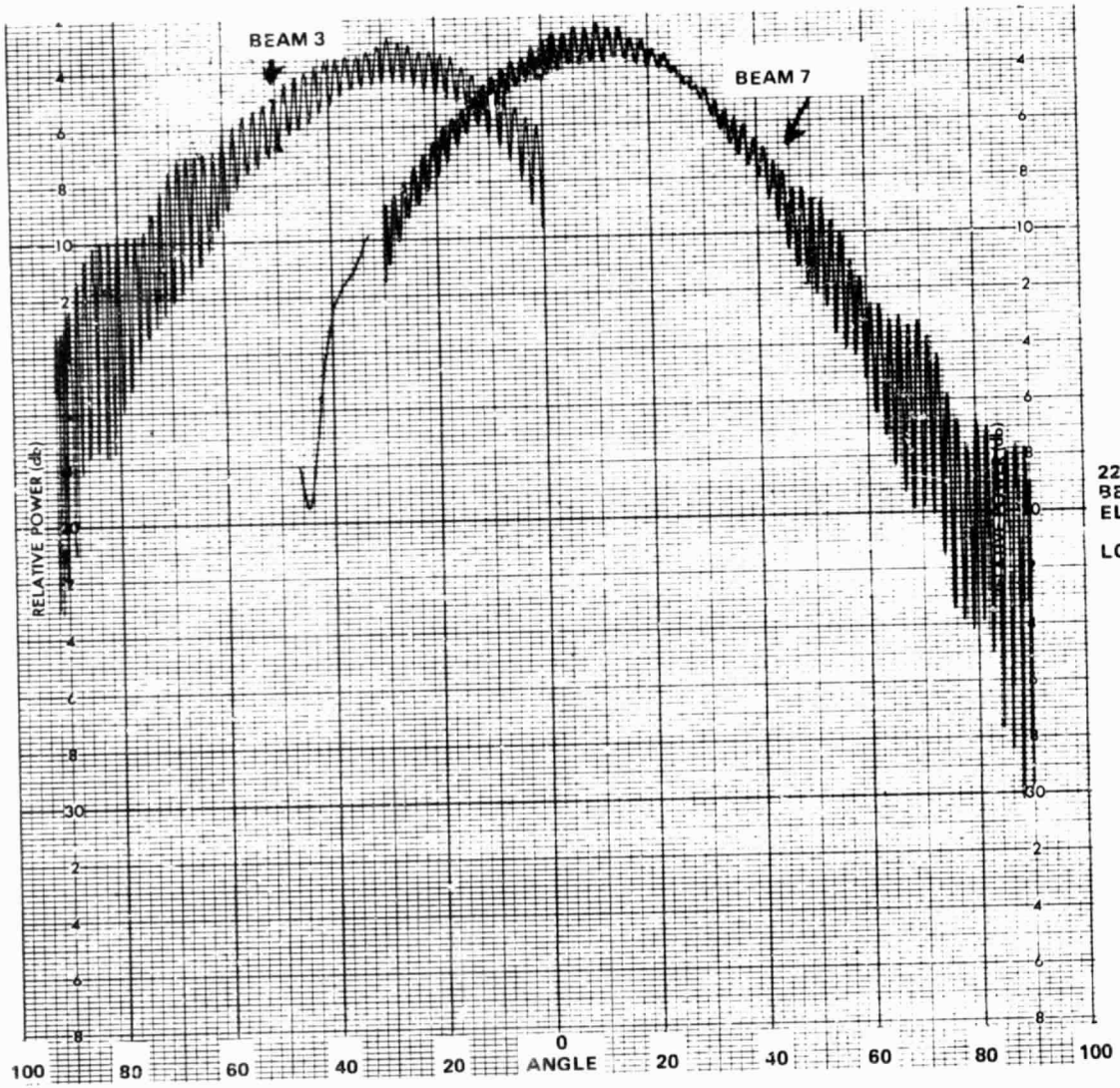
2287.5 MHz
BEAMS 1 AND 5 (ROLL)
ELEVATION: 53.5° DOWN

LOWER ANTENNA



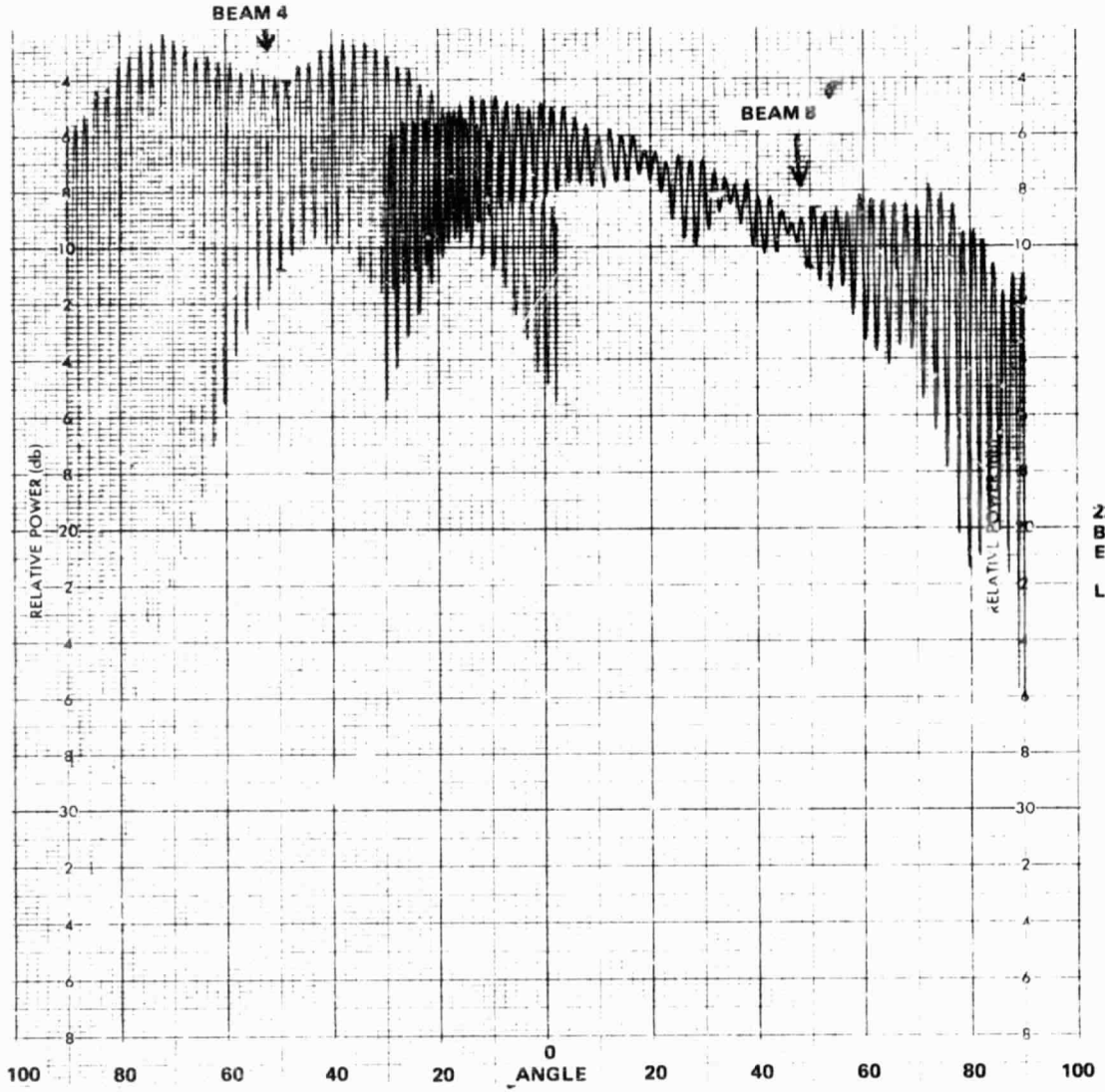
2287.5 MHz
BEAMS 2 AND 6 (ROLL)
ELEVATION: 11.5° DOWN

LOWER ANTENNA



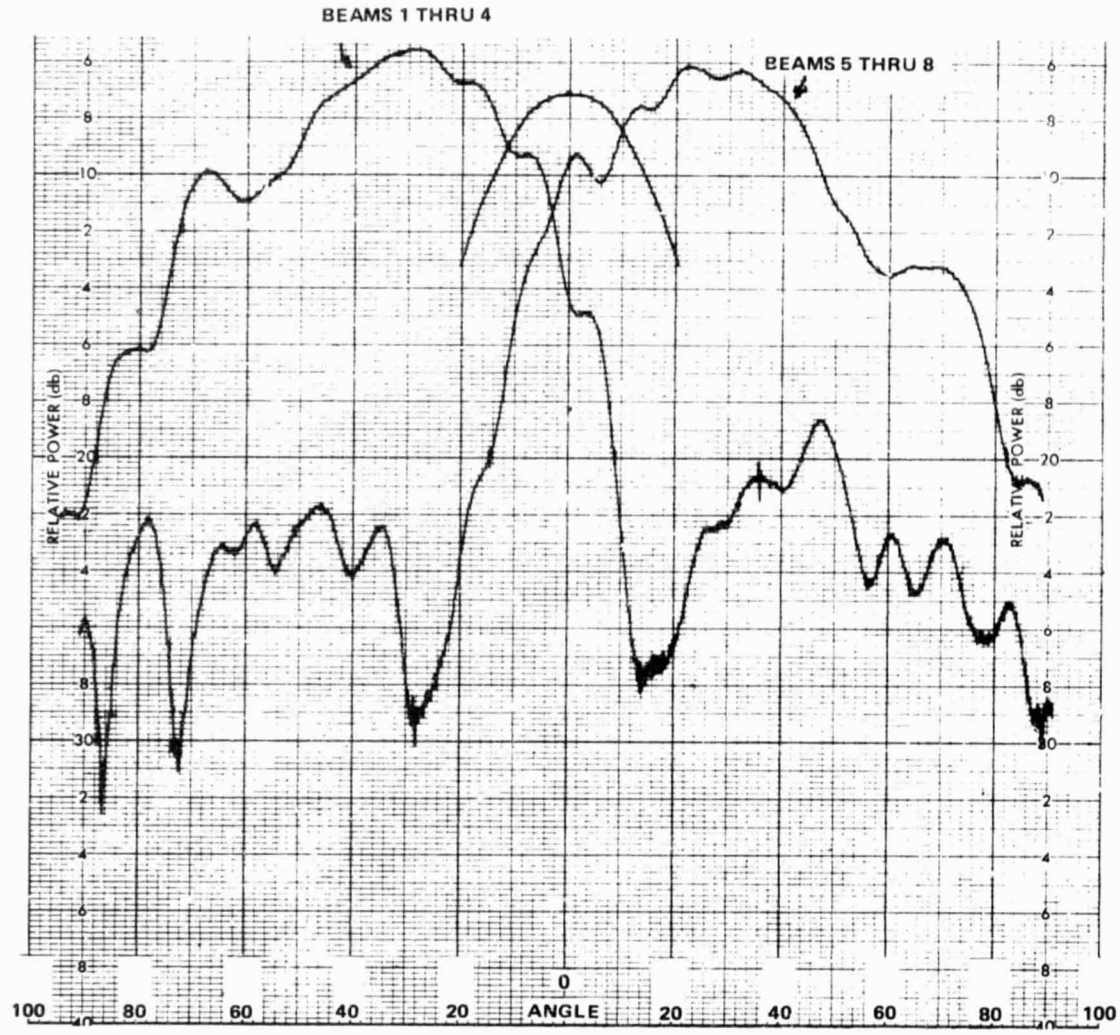
2287.5 MHz
BEAMS 3 AND 7 (ROLL)
ELEVATION: 11.0° UP

LOWER ANTENNA



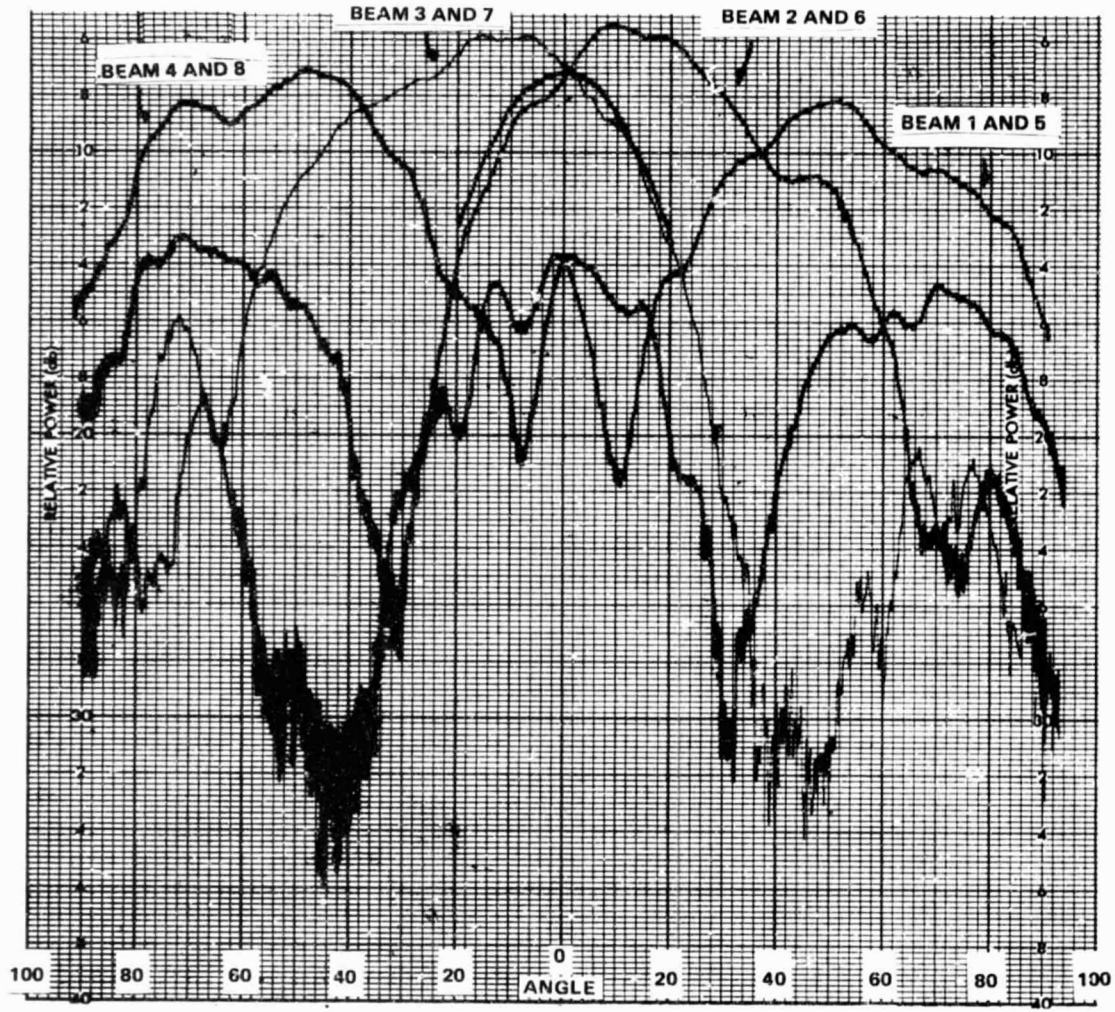
2287.5 MHz
BEAMS 4 AND 8 (ROLL)
ELEVATION: 52.5° UP

LOWER ANTENNA



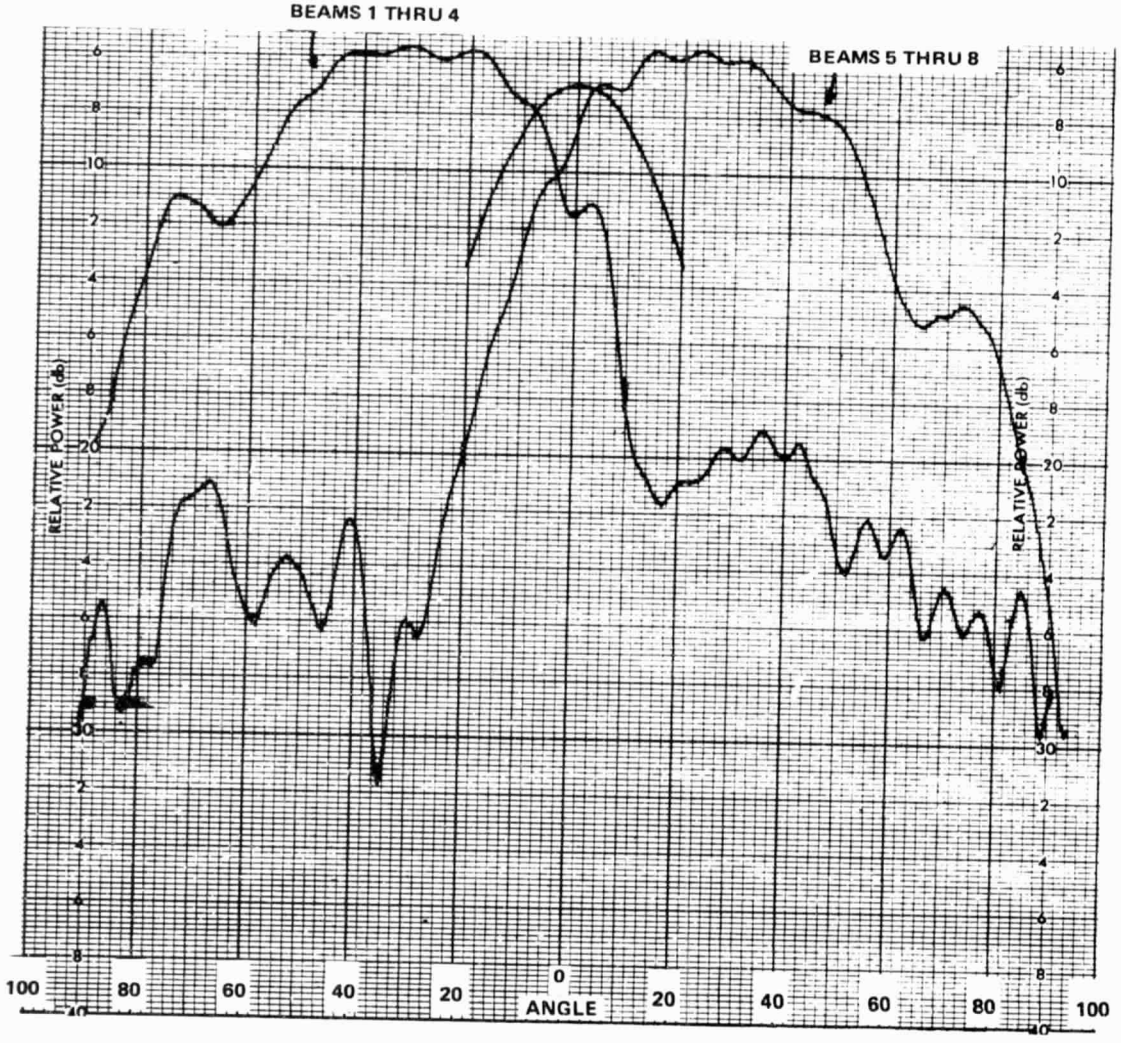
2041.9 MHz
RADIATING ELEMENTS: A-E-B
ROLL PLANE
ELEVATION: 0°

UPPER ANTENNA



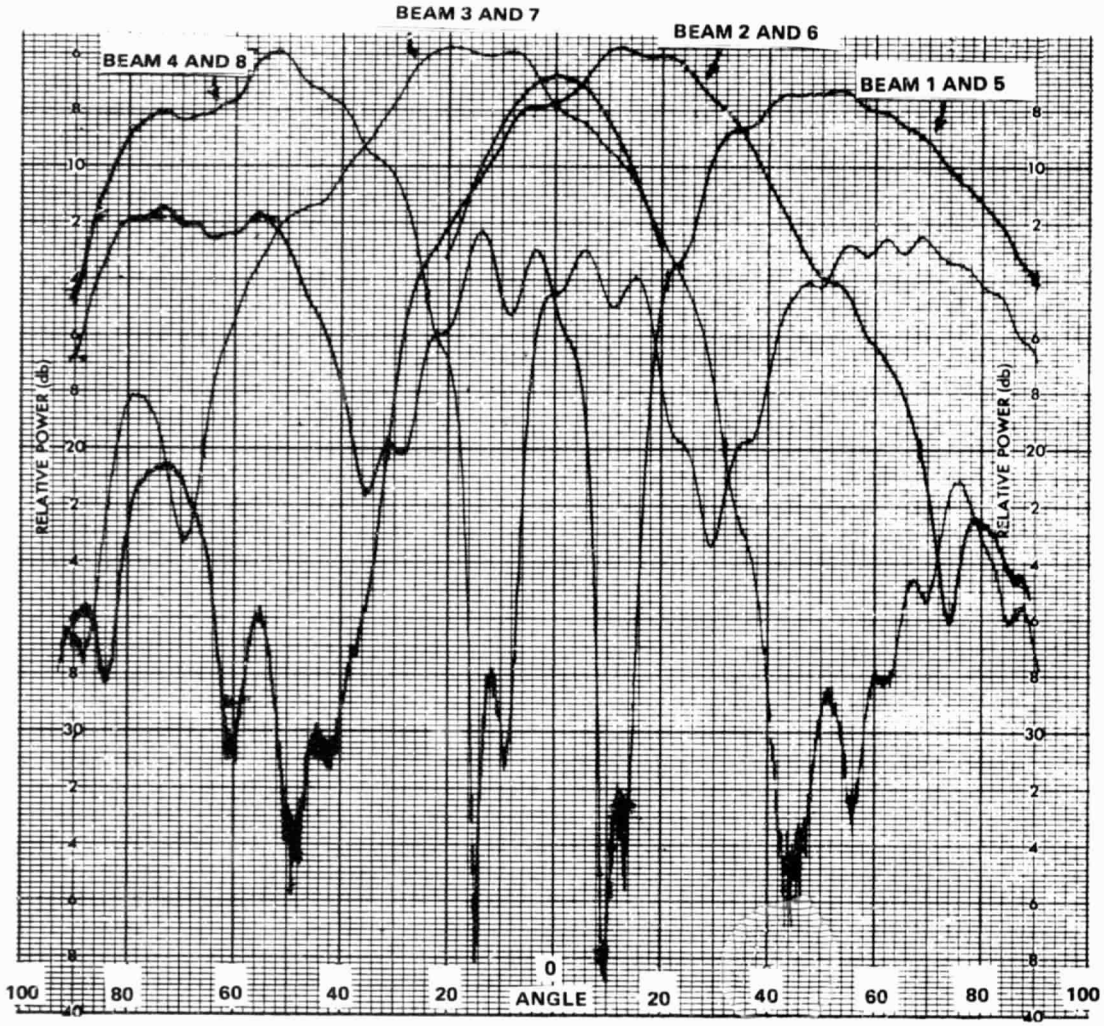
2041.9 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°

UPPER ANTENNA



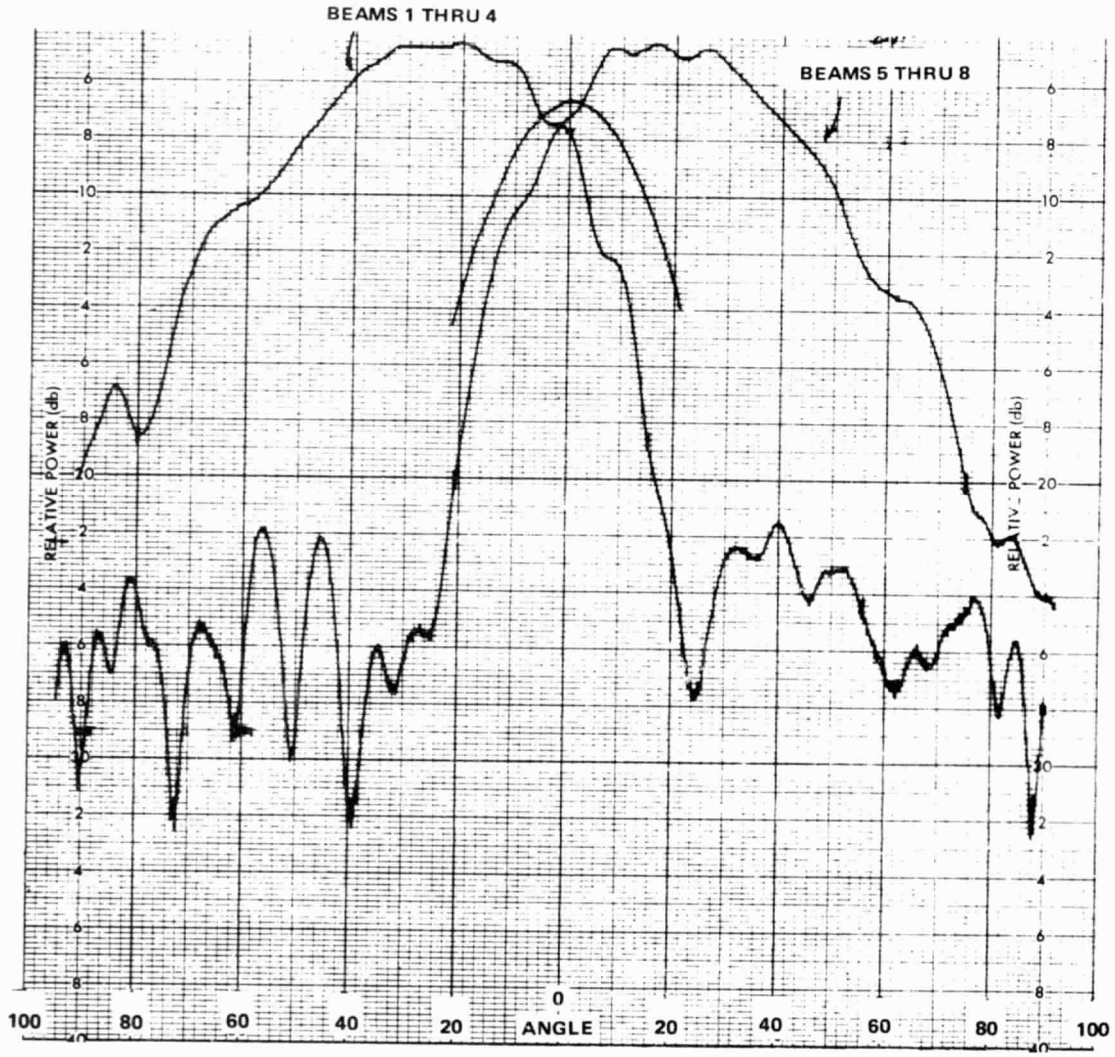
2106.4 MHz
RADIATING ELEMENTS: A-E-B
ROLL PLANE
ELEVATION: 0°

UPPER ANTENNA



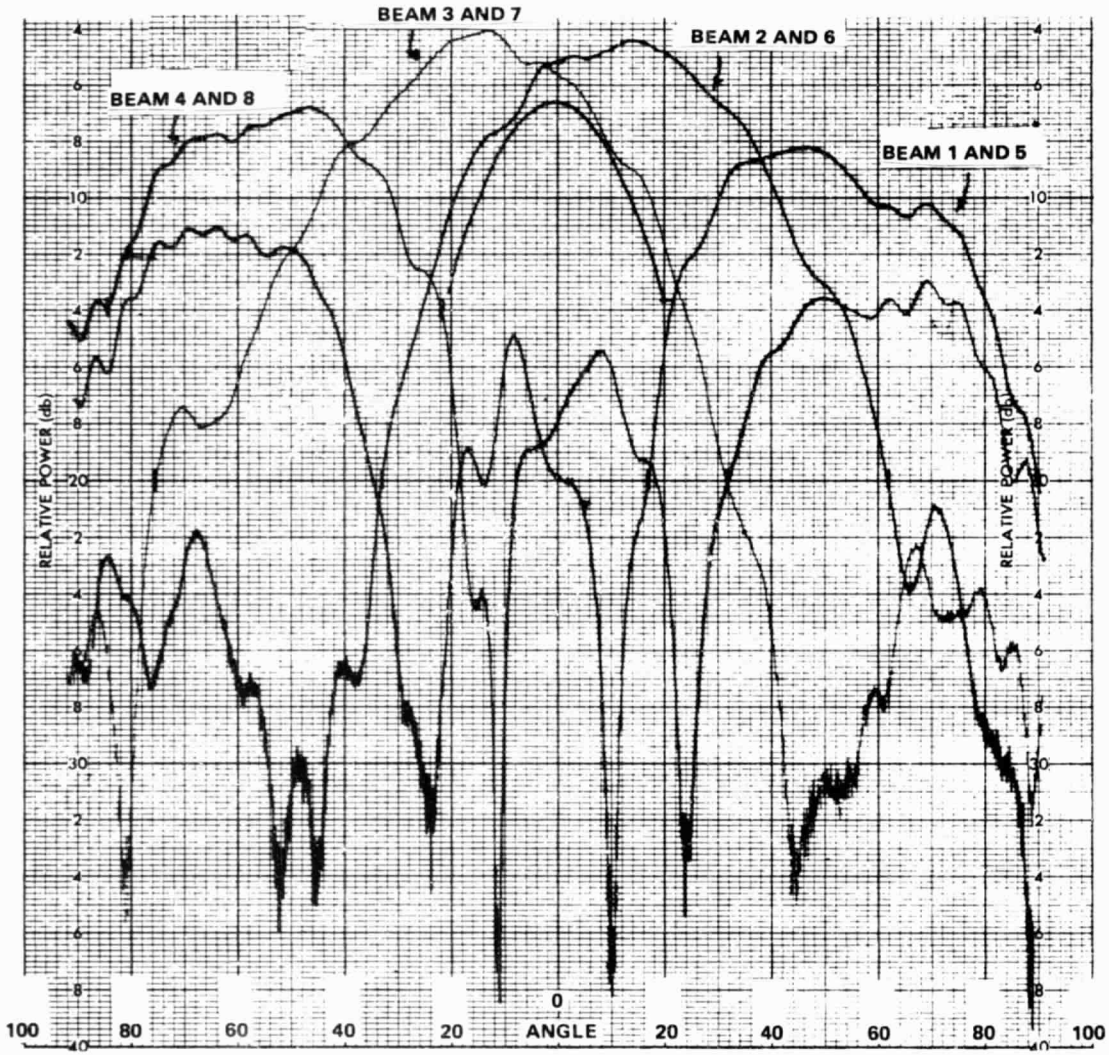
2106.4 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°

UPPER ANTENNA



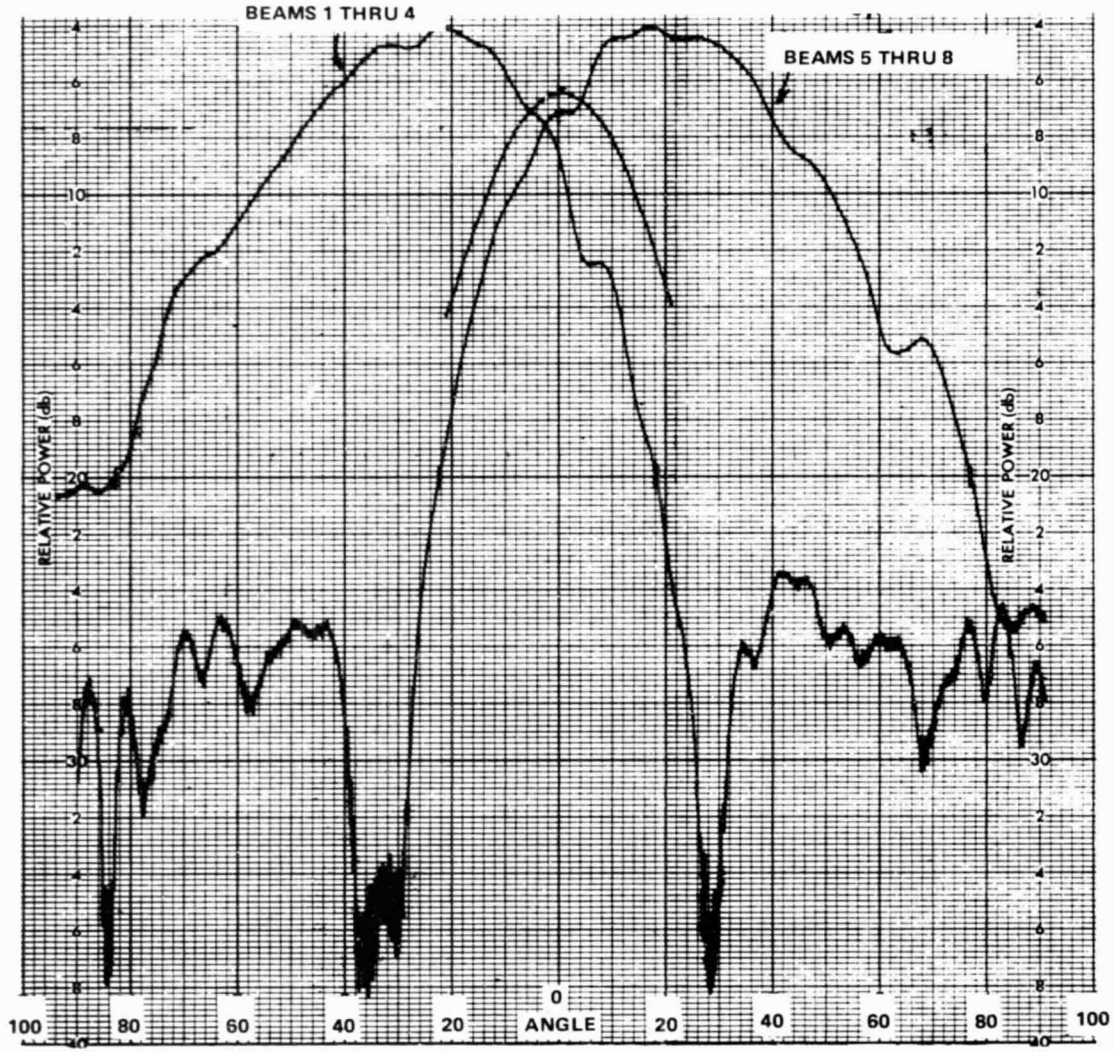
2217.5 MHz
RADIATING ELEMENTS: A E-B
ROLL PLANE
ELEVATION: 0°

UPPER ANTENNA



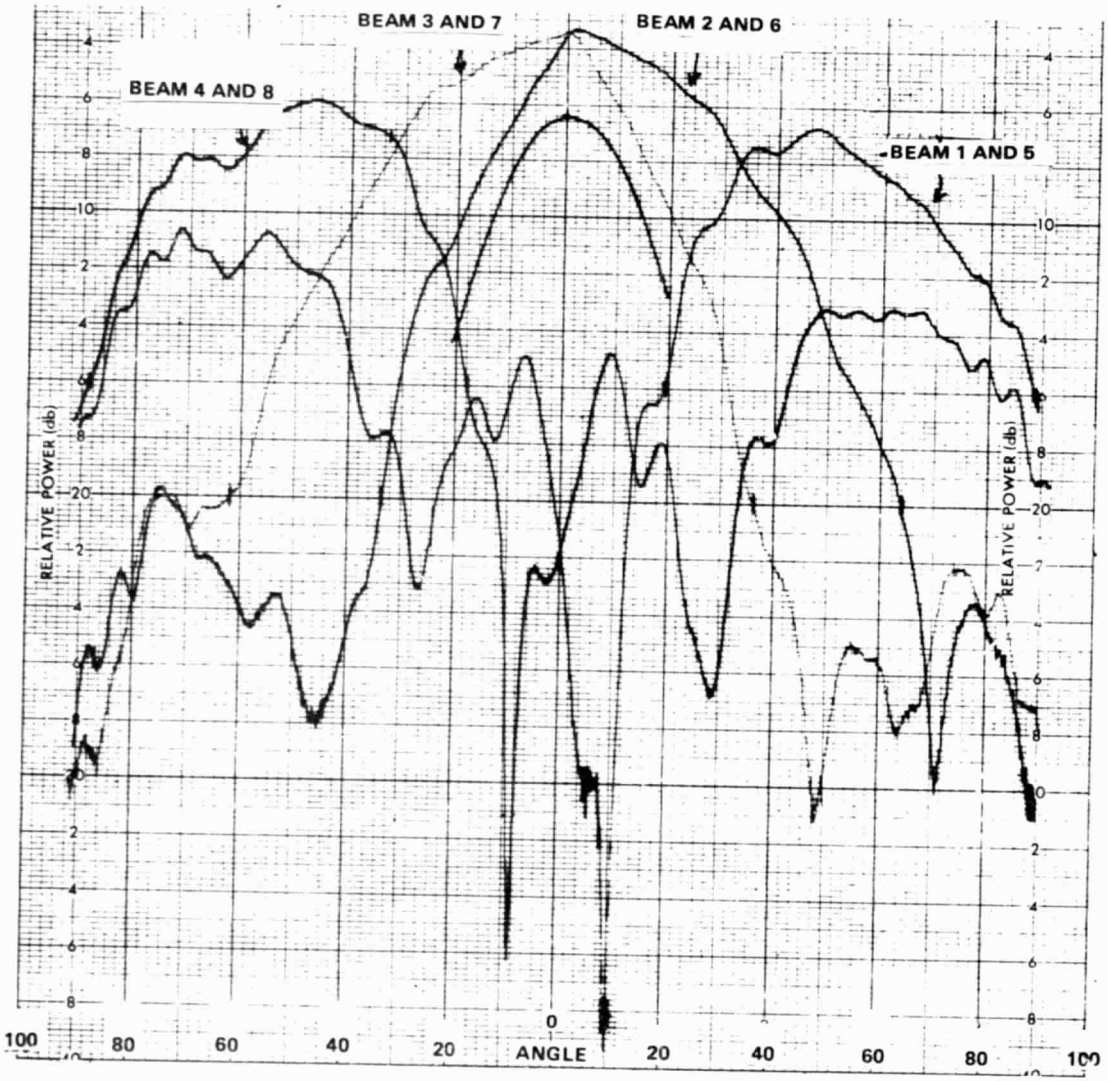
2217.5 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°

UPPER ANTENNA



2287.5 MHz
RADIATING ELEMENTS: A-E-B
ROLL PLANE
ELEVATION: 0°

UPPER ANTENNA



2287.5 MHz
RADIATING ELEMENTS: C-E-D
PITCH PLANE
ELEVATION: 0°

UPPER ANTENNA